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PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

AUGUST, 1942
Vol. 21, No. 8

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Editor

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—*The Publisher.*

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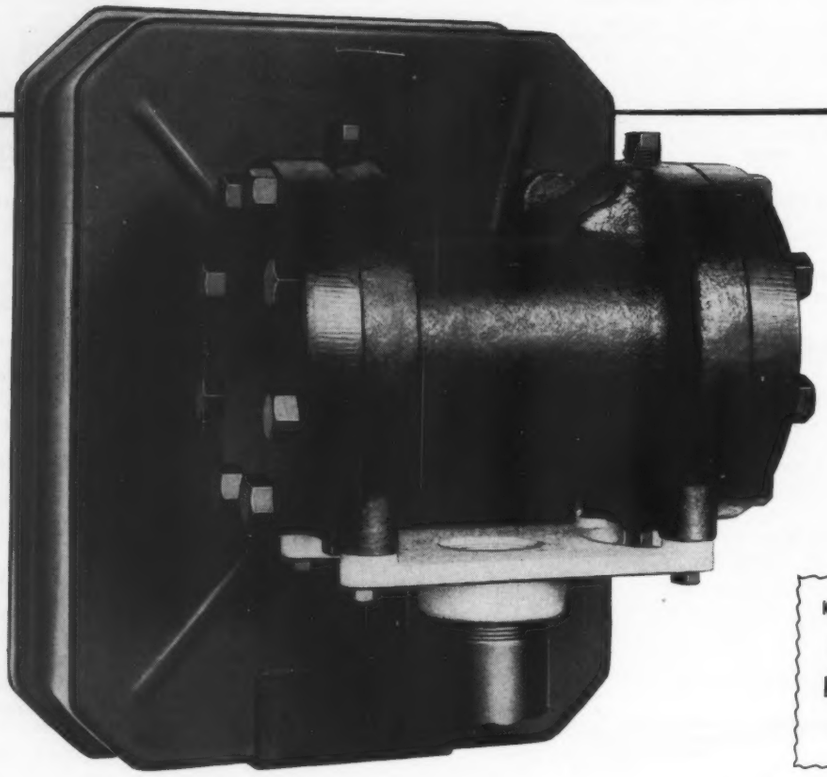

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VOLUME 21, NO. 8 AUGUST, 1942

PETROLEUM
REFINER

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

WHEN this publication entered the publishing field 20 years ago as REFINER AND NATURAL GASOLINE MANUFACTURER, straight distillation was the dominant method of recovering usable products from crude petroleum. The natural-gasoline plant recovered liquid by compression or absorption, after which its products were at the mercy of the weather.

Our New Name

Development over the period has been staggering. Thermal cracking, fractional distillation, conversion of gases to useful liquids and catalystic methods have laid the groundwork for what now looks like the dawn of a still wider advancement in conversion of the hydrocarbons. In no small way stabilization and fractionation in the natural gasoline industry have contributed to crude-oil processing.

The change in name, effective with this issue, to PETROLEUM REFINER, with appropriate designation of the wider scope of petroleum processing, is simply a move to bring the name in line with the scope of present editorial effort, plus the scope that must be maintained for future development, as well as to accomplish brevity in the name itself.

"Petro-chemical" is no idle play on words, for the petroleum refinery is now engaged in making raw chemicals for other industries, also making finished chemicals, which it may furnish to the public or leave for other distribution. It is no longer possible to restrict petroleum refining from chemical processing. Pressure of military requirements has brought this advancement ahead of any expected normal development.

Now that it is here, the chemicals now being produced and known to be available in crude oil force this industry into wider applications of finished materials. Just as REFINER AND NATURAL GASOLINE MANUFACTURER maintained a viewpoint as wide as the advancement from straight distillation into chemical processing, PETROLEUM REFINER will hold a similar viewpoint in chemical processing, petroleum synthetics and in natural gasoline.

SO CONFUSING and so unfair is the Washington attitude toward the synthetic rubber program that the impression prevails that free competition would solve the problem quicker, cheaper and more satisfactorily than direction by agencies of government. If men could work rather than go to Washington to testify and politicians could keep quiet, the plants would be built and there would be a product to take the place of natural rubber.

Competition Would Surpass Confusion

Despite all this the plants are being built and the nation will have a substitute for rubber. It is discouraging to work against political sabotage.

Low point in political bickering came in a recent report of the Senate Agricultural Committee to the effect that methods of butadiene manufacture from grain is further advanced than "untried laboratory experiments from petroleum." Members of that committee know that synthetic rubber from petroleum is in actual production and that tires from Buna S rubber are being road tested and that the butadiene in those tires came from petroleum. If that is still in the "untried laboratory" stage, what would the committee call progress?

No one doubts that butadiene can be had from grain. No one in the petroleum industry has opposed the method. Several have spoken in its behalf. It does seem pertinent to ask, however, where

the grain alcohol process was in 1940 when the petroleum industry and the rubber industry recommended to NADC that plant capacity for 100,000 tons per year of synthetic rubber be built?

That recommendation started on its spiral through political circles and dwindled as it moved. Finally private industry built some limited capacity and that is at work today. Since then plant capacity financed by agencies of government has been completed and finished materials are in use and under test. Some investigating committee could do a good turn by determining how and where that 100,000-ton recommendation was reduced to pilot plant size.

Long before December 7, 1941, the petroleum industry had much more than "untried laboratory experiments" for making butadiene and the rubber industry had much more than experiments in combining this product with other hydrocarbons and chemicals for making synthetic rubber.

If, meanwhile, through scientific development grain has come to be a cheaper and quicker source of butadiene the method should be pushed to its utmost. What leaves that possibility doubtful is that its praise comes not so much from presenting its merits as from attacks on the petroleum source. Butadiene from wheat will not be advanced by untruthful statements about butadiene from a barrel of oil.

Meanwhile scientific development within the petroleum industry is being branded as confusion. Since plans were drawn for the first butadiene unit, it has been learned that a change in operating methods will produce butylene direct from cracking stills, thus shortening the route to butadiene. More recently another established catalytic cracking process has been advanced as still another route to butadiene. Claims for each development come from men and corporations whose records warrant acceptance of claims.

These are indications of progress rather than confusion. It is characteristic of petroleum technology that its plants are headed for obsolescence while they are being built.

Even this should not be accepted as cause for discarding what has been approved. Whatever is quicker and cheaper should be tied into that under construction. That is what should be done with the promise of alcohol as a butadiene source.

Private enterprise would come to the quickest and cheapest process by such. But that would amount to competition, profits, losses, failures and successes. There is futility in suggesting resort to open competition, for that is not the way of the hour. There are three agencies in Washington, each with some control over the synthetic-rubber program. Then there are committees whose investigations seem colored by the activities of their constituency.

We can hope that the men who must build and operate the plants that will bring synthetic rubber in sufficient quantity will not be discouraged by the curious activities of agencies and committees.

Indictments Still Come Rolling Out

FOR ALL its promises to desist in matters of litigation, the federal government still continues with its harassing indictments against industry. The peculiar slant of the process is that most of the indictments involve concerns which are engaged in efforts to solve war material problems.

Earlier in the year there was a statement from high authority that this procedure would be left dormant, at least during the period when men were expected to pay attention to technical problems. It sounded like an admission that so much was expected of industry that it would not be expected to prepare defense in litigation while aiding in offense for the nation.

Now, however, indictments against the leading chemical concerns have been returned on the charge of violation of the anti-trust laws. Individuals as well as corporations are under charges. Specifically they are charged with conspiracy to fix and maintain prices.

Even the layman is puzzled by this attitude. Only recently an agency has been established in government to freeze prices. While the efforts of corporation and individuals are not identical with that of government, it is confusing to see the price-fixing effort pursued by one branch of government and to know that the Department of Justice is prosecuting on charges of price fixing.

The indictments against 22 of the large oil companies has been continued by order of the trial court. There was some hope that this would be left dormant while the industry was striving to provide more ingredients for synthetic rubber than even the most optimistic thought possible a few months back.

Silence Is Significant

FOR ALL the noise being made about development and adaptation of process of refining, it is what is not being said that is significant. There is fanfare with development. Changes can not come and progress can not be recorded without words being spoken and other words being printed.

But the investigation that goes on under secrecy offers more for the future of refining processes than the publicity. In part publicity attends what has been accomplished. Secrecy abounds where the technical men have not completed their work.

The end of censorship will bring to refining its period of evidence of additional progress. Meanwhile good words must wait.

Hydrocarbon Chemistry For the Refinery Worker

PAUL H. FAUST
Chemist, General Petroleum Corporation

THE past few years have seen remarkable progress in the industrialization of petroleum chemistry. This article is designed to present some of the phases of modern chemistry that might interest men of the oil industry. The chemical compounds of which petroleum consists are discussed by type, and the relation of rate and equilibrium concepts is mentioned. The article is concluded with a brief reference to thermodynamics and an outline of current refining methods from a chemical point of view.

The study of petroleum is basically the study of molecular structure, for without recognizing the importance of arrangement in the molecules there would be no way to distinguish, for instance, between several compounds with the same number of carbon and hydrogen atoms, but widely different characteristics with respect to combustion in an engine. Perhaps there is an excuse, then, for emphasizing

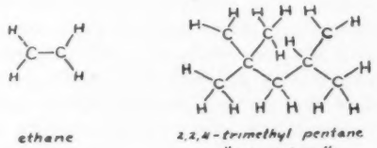


FIGURE 1

here a phase of chemistry that may seem somewhat abstract in order to lay a foundation for more complete appreciation of chemical phenomena.

A really fundamental approach would begin with electrons that are connected with atoms and molecules. But the vagaries of the electron, while conceivably interesting, are of little value in the application of even structural chemistry. For instance, while the type of interatomic link, or "bond," that we shall deal with is regarded as a pair of electrons, it can be pictured, with surprising validity, simply as a peg that joins two atoms. By diffraction and absorption spectra studies, scientists have been able to determine the angles and distances between atoms in molecules so that accurate models can be made to demonstrate the space arrangement of the atoms. Such a model is shown in Figure 2. In this article electrons will receive only one further mention—in connection with *resonance*.

Crude oil is composed primarily of chemical compounds of carbon and hydrogen, the *hydrocarbons*. Other substances exert a profound influence in refining, to be sure, but the hydrocarbons are the materials actually processed. The classification of hydrocarbons most familiar in the industry is the following:

1. Paraffins
2. Naphthenes
3. Olefins
4. Aromatics.

Paraffins

Paraffins are hydrocarbons of the empirical formula C_nH_{2n+2}, which means that any molecule of a paraffin hydrocarbon contains two more than twice as many atoms of hydrogen as of carbon. All paraffins are made up of a "chain" (which may be branched) of carbon atoms, each of which must be connected to four other atoms in accordance with the valence ("combining capacity") of carbon, four. Figure 1 shows the "structural formulas" for two hydrocarbons.

Naphthenes

Napthenes, or "cyclo-paraffins," differ from paraffins only in that the carbon chain forms a "ring" in some portion of the molecule. While the simplest naphthene contains three carbons in a triangle, there is no good evidence that rings of less than five carbon atoms occur in petroleum or its products. The five and six membered rings act almost the same, chemically, as the corresponding paraffins.

Olefins

Olefins are compounds containing what is called a double bond; a *double* connection between two carbon atoms. They are formed from paraffins or naphthenes by the elimination of two hydrogen

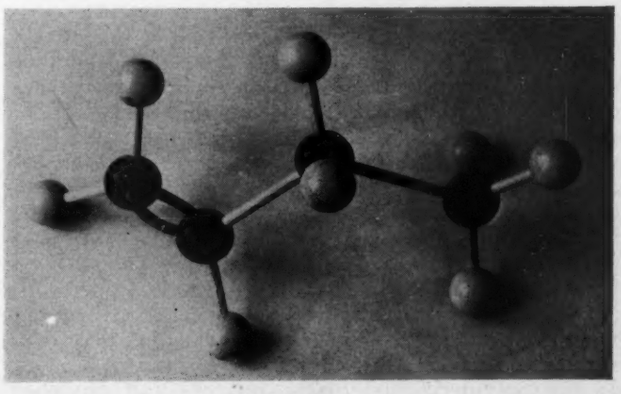


FIGURE 2

atoms from adjacent carbons, for to preserve the valence state of carbon, all four of its bonds must be occupied. Although olefins are thought not to occur in crudes, they are formed in cracking processes and even in the milder heating of the topping plant. Di-olefins which contain two double bonds, and acetylenes with a triple bond, are other types which should come under the class of olefins.

The term *unsaturates* is applied to all of these compounds because of the tendency of the multiple bond to be broken by combination with other substances. Hydrogenation, for example, is the "addition" of hydrogen atoms to a multiple bond, forming a more "saturated" compound. The chemical equation for the reaction of ethene (also called ethylene), the simplest olefin, with hydrogen to form ethane illustrates the process of hydrogenation:

$$H_2C{-}CH_2 + H_2 \rightarrow H_3C{-}CH_3$$

In the consideration of naphthenes and olefins, a very interesting concept is that of bond angles. The four bonds of the carbon atom are known to extend from the atom so as to make tetrahedral angles with one another. Figure 2 is a photograph of a model of 1-butene showing how these bond angles affect the shape of a molecule.

The bonds of a double bond must naturally be bent, and it might be imagined that this would set up a strain in the molecule, just as a strain exists in the springs used to depict the double bond in the model. The hypothesis of such a strained condition might well explain the reactivity of olefins, since any reaction involving the double bond would relieve this strain. In constructing molecular models of naphthenes one finds that the cyclo-propane and cyclo-butane rings cannot be formed without quite drastic bending of the carbon-carbon bonds, while cyclo-pentane and cyclo-hexane can be fitted together with a minimum of strain. This explains why five- and six-membered rings occur almost exclusively in naphthene fractions from petroleum, and why cyclo-propane behaves more like an olefin and cyclo-pentane, like a paraffin.

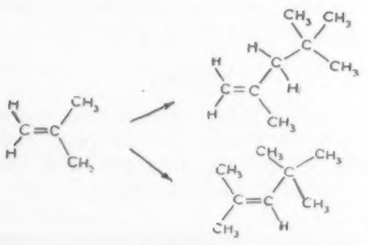


FIGURE 3

Further substantiation for this "tetrahedral" structure of hydrocarbons is found in the study of the spreading of monomolecular films on the surface of water (a method used to determine the overall dimensions of a molecule). The lengths of hydrocarbon chains are so found to be shorter than the theoretical length calculated on the basis of a straight chain. In fact, calculations show that the carbons must be joined at the tetrahedral angle (109° 28′).

Olefins have the important property of reacting with each other to form "polymers" which may consist of two or of thousands of the original molecules. In the polymerization of the butenes and propenes (C_4 and C_3 olefins) to form constituents of gasoline, conditions are maintained so as to form a polymer of just two olefins, a "dimer." In the synthetic rubber industry, on the other hand, polymers of several thousand units are formed. The polymerization of iso-butene to two possible "di-isobutenes" is illustrated in Figure 3.

It may be of interest to note that these particular products are made commercially (U.O.P. and Polyco catalytic polymerization plants), and subsequently hydrogenated to form 2,2,4-trimethyl pentane, the so-called "iso-octane" upon which the octane scale is based. The hydrogenation is necessary if the iso-octane is to be used in aviation gasoline, since the reactivity of the double bond causes oxidation and gum formation which is especially dangerous in the airplane engine. For motor gasoline, however, such polymers can usually be used as blending agents without fear of exceeding gum requirements.

The rubber molecule (whether natural or synthetic) is what is called a "high polymer." It has no definite length, although it is made up of quite definite molecular units, as will be seen presently. The physical character of rubber derives from the nature of these rubber molecules, which consist primarily of long chains of carbon atoms as in Figure 4.

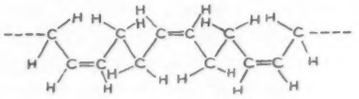


FIGURE 4

The flexibility of rubber is a result of the possibility of rotation about the single carbon to carbon bonds which allows free bending of the chains. When stretched, the ordinary random distribution of these chains is altered and, they tend to assume a parallel orientation with respect to one another. X-ray diffraction data indicates that a crystalline structure may be formed in stretched rubber as a result of coincidence of several strings of evenly spaced groups. Heat is developed in stretched rubber by intermolecular friction, and in some cases care must be taken in the milling of rubber to prevent this heat from becoming excessive.

One might expect that the chains in stretched rubber would tear apart easily and cause permanent deformation. To prevent this very thing rubber is vulcanized. In vulcanization, cross bonds are formed betweeen the various chains by chemical combination of sulfur with the double bonds in the chains. Enough sulfur may be used to form "hard rubber," but ordinarily just enough to prevent permanent deformation over a reasonable temperature range is employed. The hardening of the surface of rubber with age is a result of the same sort of thing as extended vulcanization, but here the oxygen of the air takes the place of sulfur. The excellent chemical stability of butyl rubber might be attributed to the fact that the number of double bonds in the chains can be made low enough so that after sufficient vulcanization, no more will remain. This is possible because butyl rubber is composed mainly of mono-olefins (usually iso-butene) with just sufficient butadiene to make adequate vulcanization possible.

The polymer of a mono-olefin obviously contains few double bonds since for every olefin molecule added, a double bond is broken. On the other hand,

rubbers derived from di-olefins such as butadiene contain many double bonds.

Rubbers of the butadiene type, including those from butadiene (Buna rubbers), chloroprene (Neoprene and Duprene), and isoprene (natural rubber), all appear to have been formed from units of the form: ——C—C=C—C——, and not from the butadiene molecule as ordinarily written:[1] C=C—C=C. This shifting around of the bonds is explained as resulting from a condition called *resonance*,[2] which allows the substance to exist in both forms. The formation of the butadiene-styrene co-polymer, Figure 5, illustrates this surprising behavior.

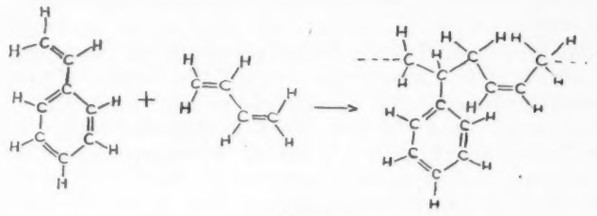


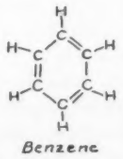
FIGURE 5

The form of butadiene in which free bonds appear at the end carbons is the more reactive, so that polymerization always occurs with these molecules end to end. Aside from aiding materially the study of rubber this fact undoubtedly is of significance in the preparation and properties of synthetic rubber.

The materials that the petroleum industry will contribute to the synthetic rubber program are butadiene, iso-butene, styrene, and probably other mono-olefins. Butadiene does not occur to an appreciable extent in ordinary refining operations, so plants have been built to convert normal butane and butene to butadiene by high temperature, low-pressure dehydrogenation. Catalysts may be used in this operation. The unreacted butane and butene are not readily separated from the butadiene as the boiling points lie within a very short range. However, there is a method of absorbing butadiene in copper chloride ($CuCl_2$) which can be used for its isolation. The major constituent of butyl rubber, iso-butene, can be recovered from waste refinery gases without further processing, which makes the raw materials for this type comparatively cheap.

Aromatics

Aromatics are a special class of hydrocarbons which contain an atomic configuration known as the benzene ring. This consists of a ring of six carbons with three double bonds.



Benzene

FIGURE 6

As would be expected from the double bonds in benzene, it can be hydrogenated in the same manner as an olefin, but the reaction, strangely enough, is a comparatively difficult one to carry out. The explanation of this anomaly lies in *resonance*, one of the most important concepts of structural chemistry. Resonance is defined in the somewhat terrifying statement that *when a molecule can exist in two or more electronic structures of nearly the same energy content, the state of minimum energy content for this molecule* (the state in which it actually exists) *is one of rapid oscillation, or resonance, between the possible structures.* It is easy to see what this means if we realize that the bonds making up the structural formulas used actually represent electrons, and a rearrangement of those bonds is equivalent to the formation of a new *electronic structure* for the molecule. Note that only the double bonds move, not the atoms themselves. In the case of benzene, there are the possible arrangements of bonds in the molecule, and the actual state of the ring is a rapid oscillation from one to another of these forms shown in Figure 7.

FIGURE 7

The stability that resonance imparts to benzene and all aromatics is the reason for their lower reactivity. For instance, the six-membered ring containing one double bond (cyclo-hexene) cannot resonate, and is quite reactive toward bromine; while the same ring with two more double bonds (benzene) does resonate, and reacts with bromine slowly. This stability is of interest to the refiner because of the resistance to cracking it imparts. It is well known that aromatization is brought about by strenuous cracking conditions, and in fact, one of the major factors contributing to increase in octane rating by cracking is the formation of aromatics. The stability of the benzene ring structure is fortunate, in view of its high octane rating, because the long side chains on aromatics already occurring in crudes can be cracked down to chains of one or two carbons without threatening the ring structure at all. Thus high-boiling aromatics are reduced to those boiling in the range of gasoline and aviation fuel.

Rate

Whenever one substance is converted into another, a chemical change is said to take place. There are two fundamental things about a chemical change that we should note; first, its rate, and second, the extent to which it can go. Although it may seem the simpler, actually the concept of rate is much less understood than the concept of extent, or equilibrium. Some factors upon which the rate depends are activation energy, orientation, collision rates, and restrictions to the transfer of energy. These are affected by temperature and by the degree of dispersion or mixing of the reactants, and may also be altered by external agents called catalysts.

Catalysis might be defined as the hastening of the attainment of equilibrium by means of a substance, the "catalyst," which is not, itself, consumed in the reaction. Lately, catalysis has become a household word in the oil industry; cracking, isomerization, polymerization, alkylation, hydrogenation, and dehydrogenation are all accomplished by catalytic means in commercial plants.

Two types of catalysis can be recognized in refining processes. One type employs a solid catalyst

such as activated clay (in Houdry catalytic cracking), alumina, chromium oxide (in dehydrogenation of butane to butadiene), and various other oxides or sulfides. The solids are handled in the form of a powder, or more satisfactorily as pellets or a coating on some inert "carrier." These catalysts usually promote such changes as cracking, rearrangement, and dehydrogenation. Their action involves the "adsorption," or concentration, of the reactants on the *surface* of the catalyst where molecular deformation may ensue with a consequent activation of the adsorbed molecule. Anything which might act to prevent the reactant's access to this surface naturally would stop the catalytic action, and when this happens the catalyst is said to be "poisoned." Sulfur and accumulations of coke are poisons well-known in the refining of oil. Metals such as iron have a marked catalytic effect on hydrocarbons, but they are poisoned so readily that no catalytic action is observed even in iron cracking tubes, except possibly in vapor-phase processes.

The other quite distinct type of catalyst is one which combines with a reactant to form an "intermediate" compound which subsequently reacts in such a way as to free the catalyst again. Catalysts of this type are usually used to promote alkylation and polymerization reactions. The mechanism of catalytic alkylation showing the restoration of the catalyst is illustrated in Figure 8.

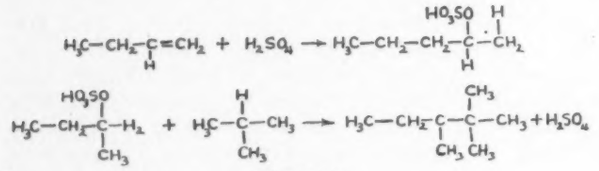


FIGURE 8

These catalysts are often fluids, such as sulfuric acid (Kellogg and U.O.P. catalytic alkylation), phosphoric acid (often used also on a solid carrier), and hydrogen fluoride (in a new alkylation process), but several solids such as aluminum chloride (Shell butane isomerization), and copper pyrophosphate (Polyco catalytic polymerization) are also in current use. These catalysts, since they do not depend to such an extent on surface phenomena, are not poisoned as readily as the former type. The liquids, however, gradually become diluted with water and side-reaction products until they must be replaced. It should be emphasized here that no catalyst can cause a reaction to proceed beyond a certain "equilibrium" state. The use of a catalyst is to hasten the attainment of this equilibrium, or sometimes, to cause one reaction to proceed towards equilibrium when, ordinarily, another reaction would be more inclined to occur. For example, dehydrogenation under certain conditions is less likely to occur than splitting of the carbon chain, but a catalyst can be used that will hasten only the dehydrogenation so that splitting does not have a chance to proceed to an appreciable extent.

Equilibrium

We have seen that reactions tend to go only so far—namely, to *equilibrium*. This means that for given conditions of temperature and pressure, there is a ratio of products to reactants in any reaction that cannot be exceeded.[3] This ratio is expressed in the form of a so-called *equilibrium constant*, but it should be emphasized that the value of this "constant" changes with variations in temperature. Sometimes when the temperature is increased in order to hasten the attainment of equilibrium, the yield may be reduced because of a more unfavorable equilibrium state at the higher temperature. For this reason, a compromise frequently must be struck between the equilibrium and the temperature in order to obtain a maximum conversion. In this situation, catalysts often may be substituted for a temperature rise with excellent results. The use of aluminum chloride in the Shell isomerization process is an illustration of this, for the equilibrium in such isomerization reactions indicates a much higher conversion at lower temperatures.

Development work is aided materially if pertinent equilibrium constants are known, for then experimentation need only be applied to find methods to increase the rate instead of being extended to determine what reactions are possible. Furthermore, processes may be rated on "percent of theoretical conversion" in order to determine their chemical efficiency. Obviously, equilibrium constants are extremely useful to the oil refiner, and methods of obtaining such constants are important. Among the several applications of thermodynamics to refining are means of calculating this data, for the thermodynamic function, *free energy*, is connected very closely to the equilibrium constant.

Thermodynamics

With the current increasing interest in the application of thermodynamics to engineering problems, and the consequent increase in available thermodynamic data, the usefulness of this technique is increasing. Thermodynamics, as applied to chemistry, is the study of the heat and work effects accompanying chemical changes.

In petroleum chemistry, the two concepts "free energy" and "enthalpy" are of major interest. These concepts might be compared to other properties of a substance, such as specific gravity and boiling point, in that they are definite for a given substance at given conditions. They can be compiled and referred to as descriptive data. Fortunately, their use can be appreciated without any understanding of the underlying theory, and indeed, any attempt to present the theory of these functions would be out of place here. It should be noted however, that there are several methods of obtaining enthalpy and free energy data from other thermodynamic functions ("energy content" and "entropy" for instance), as well as from calorimetric or spectroscopic data. Therefore, one need not be discouraged if the particular free energy or enthalpy value he seeks is not to be had.

The application of enthalpy values is primarily in determining the heat effect of a reaction. For instance, the problem of whether a reaction need be heated or cooled in order to maintain in it a given temperature, as well as how much heating or cooling may be necessary, is solved simply by means of adding up algebraically the enthalpys of the reactants and the products of all the reactions that occur, and determining the net effect in terms, say, of calories per barrel per hour. Such an application is useful in many modern catalytic processes, including alkylation, polymerization, and cracking.

The free energy of a reaction is connected by a simple relation[4] to the equilibrium constant of the

reaction, so that free energy data is used primarily to determine how far a reaction can proceed. Expressions[5] can be obtained (from heat capacity and heat of reaction data, for instance) which show the change of free energy with the temperature, so the effect of temperature on the theoretically possible yield in a reaction can be calculated.

Refining Methods

Several industrial processes have been mentioned above in various connections, and perhaps a systematic presentation of the types of conversion currently practiced would be apropos at this point.

Fractional distillation is utilized primarily for the separation of groups or "fractions" of hydrocarbons with different boiling ranges, and the chemical changes which occur in this operation are of minor importance.

Cracking occurs when hydrocarbons are subjected to temperatures above 700° F., although commercial processes usually employ a temperature somewhat over 900°. Vapor-phase (low-pressure) cracking may be carried out at 1100° F. With heavy charge stocks, milder conditions are necessary (as in viscosity breaking) since the larger molecules are more unstable toward splitting. Reforming on the other hand, deals with the smaller, more stable molecules of naphtha and kerosine, and the temperature required may be 200 higher than for viscosity breaking. Catalytic cracking, as in the Houdry process, is carried out at temperatures only slightly lower than those of "thermal" cracking and the catalyst functions in increasing the secondary reactions of alkylation, polymerization, and isomerization. The result is a gasoline of considerably higher octane rating. Any centralization of a molecule, such as branching or cyclization, will increase the octane number, and usually the presence of a double bond is helpful in this respect.

The reactions that occur first in cracking are fission of carbon-carbon bonds to form an olefin and a paraffin from a larger paraffin, and "dehydrogenation" (carbon-hydrogen bond fission) to form an olefin from a paraffin of the same number of carbon atoms. The shorter of these olefins tend to undergo polymerization and alkylation reaction while those containing chains of five or more carbons may form naphthenes. (Figure 9.)

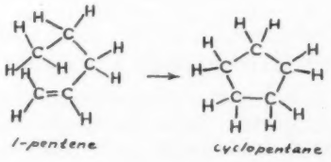


FIGURE 9

Naphthenes with six-membered rings dehydrogenate to aromatics, which eventually react with each other to form the very complex substances of which coke is now believed to consist. Thus coke is formed only after a number of preliminary reactions. It is possible to virtually eliminate coking if the cracking conditions are maintained for a sufficiently brief period. The practices of "quenching" and "delayed cracking" can be more clearly understood in the light of this mechanism for coke formation.

Polymerization and *alkylation* occur in the ordinary cracking operation, but many of the gaseous hydrocarbons (the C_2's, C_3's, and C_4's) do not react and are recovered in the stabilizer. Either these gases may be mixed with a naphtha and cracked again to form an intermediate gasoline fraction (the gas reversion and polyform processes), or they may be polymerized or alkylated by themselves in units designed for that purpose. The two processes, alkylation and polymerization, because of the highly branched character of their yields, are assuming great importance in the manufacture of blending stocks for high octane gasoline.

The chemistry of polymerization has been dealt with under olefins. Quite moderate temperatures are desirable to prevent cracking, and with the use of catalysts (chiefly sulfuric and phosphoric acids) these are possible.

Alkylation, apparently similar to polymerization in purpose, has the added advantage of consuming paraffins as well as olefins. The reaction for the "alkylation" of isobutane with normal butene, the most successful to date of the alkylation reactions, is shown in Figure 8.

Isomerization as applied to the petroleum industry is the conversion of straight-chain to branched-chain molecules. The need for iso-butane in alkylation has emphasized the isomerization of normal butane. The new Isomate process isomerizes pentanes and hexanes to form a product that can be used directly in gasolines. The significance of this process lies in the great improvement in octane rating that branching brings about.

In conclusion, it is hoped that this paper has fulfilled in some degree its purpose: to offer a chemical point of view from which petroleum processing may be regarded. That the attainment of such a viewpoint is of value cannot be doubted in these times when oil is giving birth to a new chemical industry. No mention has been made of the specifically chemical side of the petroleum industry, since it has been desired to emphasize the applicability of chemistry to those now acquainted only with the more well-known refining methods. Surely, acquaintance with the subject of chemistry can leave no one in the industry in doubt of the future of petroleum.

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[1] Frequently in discussions of hydrocarbon structure, the hydrogens or other groups are omitted from the formulas.

[2] See the section on aromatics for further mention of resonance.

[3] However, if the unreacted substances can be separated and submitted to the same conditions again, more products are formed in accordance with the same ratio. This is the theory behind the recirculation that is practiced in so many processes.

[4] $-\triangle F = RT\ln K$ where $\triangle F$ is the free energy change in the reaction, T, the temperature, and K, the equilibrium constant.

[5] Of the form: $\triangle F = a - bT\ln T + cT - \frac{1}{2}dT^2$ where a, b, c, and d are constants.

Asphalt Paving Emulsions Properties, Uses and Tests

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FROM earliest times naturally-occurring asphalt and petroleums containing asphalt have been a source of cheap binding materials which man has found readily available for construction purposes.

Bituminous materials are practically insoluble in water, and the desire to obtain asphalt in a non-viscous or "dilute" form without heating it, and to obtain it in a state wherein, upon application it would function rapidly as a binder, led to the use of water as a "carrier" for the bitumen.

There are two kinds of emulsions: Water-in-asphalt, and asphalt-in-water.

What determines either type is dependent, to a large degree, upon the nature of the emulsifier (whether water- or oil-soluble), and the structure of the adsorbed film which the emulsifier furnishes the dispersed asphalt particles in order to prevent their coalescence.

Emulsions of the first class, in which water is finely dispersed in asphalt (which is the outer phase), are not commonly employed for paving purposes as they ordinarily are difficult to dilute with water and have, as far as is known, a limited application. Roofing cements, mastics, and certain printing inks are of this class. Emulsions of this kind are known which may contain as much as 50 percent water as the inner phase. They are most commonly represented by the oil-field type of petroleum emulsions.

Asphalt emulsions of the second kind are colloidal dispersions of definite grades of adhesive asphalt (called the dispersed or inner phase) in water, which is called the dispersion, outer or continuous phase. They are made by mechanical means, such as mixing, with the addition of a necessary third substance called the emulsifier. Emulsions of the first type can be diluted with more oil or asphalt. The second type can be diluted with water, since it is the external-phase material. Each of the three components of an emulsion will be systematically discussed below.

Emulsions Used in Paving

Emulsions most commonly used in paving construction work are those of the second class wherein the asphalt is dispersed in water and they can therefore be diluted with water on the job when necessary.

Historically the first effort in the United States to make an asphalt emulsion dates back to 1869. This is covered by U. S. Patent 85623. Here asphaltic residues, resins, and rubber were emulsified in water with silicate of soda. The first commercial impetus was not evident until about 1908 when Van Westrum emulsified asphaltic oils and in 1910 obtained a basic patent for a procedure to make asphaltic emulsions. There were some patents before this time.

Emulsions of asphaltic petroleum and ammonia were used as dust-layers in 1905 on Staten Island, New York. In August, 1906 the same product was used on the Midway Plaisance in Chicago with good results.[1] M. H. West, assistant superintendent at Lincoln Park, Chicago, used soap asphalt-emulsions in May, 1907. An emulsion of asphalt, resin, soap and water was used later in Chicago in 1909 with excellent results in Lincoln Park.[2] The Westrumite Company of Chicago laid a number of pre-mixed, so-called cold-laid pavements in 1908-09 in Chicago and Whiting, Indiana, using asphaltic emulsions.[3] Since 1910 a large number of patents have appeared, especially during the period following World War I.

In the early days the making of emulsions was very much a rule-of-thumb procedure, finally becoming something of an art with involved instructions for mixing, etc., and the use of many types of crude fats, resins, pitches, all kinds of soaps, and a host of miscellaneous materials. The many efforts and contributions of asphalt technologists and chemists have, in recent years, brought this now specialized field of colloidal phenomena and asphaltic preparations closer into the realm of exact knowledge; however, many patents on this subject today (some varying by only minor details) are evidences of lingering time-worn empirical rules of procedure. It is the object of this discussion to present the important characteristics and some of the basic properties and constituents of asphaltic emulsions in the light of modern physico-chemical conceptions.

Why and Where Asphalt Emulsions Are Used

Before discussing the properties of asphaltic emulsions the reader will wish to know why and where such emulsions are used. As stated before, water was readily available for use as a "carrier" agent for asphalt, and with the proper type of emulsifier a fair emulsion resulted. It was found that upon applying the emulsion to mineral aggregates, for instance, the emulsion deposited its dispersed asphalt soon thereafter; in other cases it was found that the emulsion did not "break" at once upon application to stone but would only deposit its dispersed asphalt once the water began to evaporate.

The use of kerosine, gas oil, or other oils as "thinners" (cutbacks) followed later with the appearance of uniform penetration petroleum asphalt and modern refining methods. Apparently asphalt emulsions antedate the cutbacks. The unique feature that an emulsion will "break" and yield a film of asphalt

(the binder) as a deposit on the material to be coated has become a basic or prime characteristic for all asphalt emulsions. In other words, these emulsions are useful for their ability to form a uniform, water-impervious, and thin film of adhesive asphalt upon being applied to solid surfaces in the cold; being a dispersion of asphalt-in-water, which is the outer phase, their viscosity can be easily reduced if need be by adding more water.

Secondly, with water as the outer phase these emulsions can be applied to surfaces which are damp or wet, which means that paving aggregates need not first be dried. Asphalt emulsions today are so manufactured as to "break" within certain time periods, yet must be fairly stable in storage to yield a film of binder asphalt of required characteristics.

The above properties make asphalt emulsions unique engineering materials in:

1. Water-proofing structural masonry, such as in concrete dams and as integral water-proofing compounds for Portland cement, concrete, or mortar; 20-30 percent by weight on the cement is said to increase the tensile strength by 10 percent without affecting the setting qualities of the cement.
2. Rot-proofing of timber, and rust-proofing of submerged iron pipe as in pipe dips, pipe coatings, etc.
3. Water-proofing and coating of dark-colored fabrics, water-proofing paper and some types of saturated roofing felts.
4. Paving construction.

The most extensive application of asphalt emulsions is in paving construction and maintenance, which divides itself into constructing the top roadway or wearing surfaces, and the comparatively recent use in soil stabilization; that is, the preparation of the highway soil subgrade. Not only is the type of emulsion itself dependent upon the emulsifier, as stated above, but the speed with which emulsions will "break," or can be made to deposit a film of asphalt on the material to be coated, depends to a great extent upon the solubility of the emulsifier in either or both phases, its surface activity, and other factors which we will discuss in another part of this paper.

The rate of "break" is of prime importance in connection with the mode of applying emulsions in paving work. According to the rate at which emulsions will "break" they have been grouped into three classes: Fast-breaking type; medium-breaking type, and slow-breaking type.

Emulsions in Paving Construction

It is important to point out here in what type of road construction the above-mentioned three kinds of asphalt emulsions are used. Paving technologists recognize generally two types of construction:

1. Penetration method, and
2. Mixing method:
   a. Pre-mix pavements,
   b. Road mix pavements.

The three types of emulsions are used in the following forms of paving construction:

1. Fast-breaking type of emulsions are used for penetration construction only; for surface treatment of existing pavements or roads in wet or dry weather; and for all other types of surface treatment, such as dust-laying and sealing of pores. The average content of asphalt in the emulsion is about 50 percent. Fast-break emulsions are very sensitive to any foreign substance or surface which changes the equilibrium of the system and the dispersed asphalt particles coalesce as soon as the emulsion contacts the road material; this occurs in most cases even before the water in the emulsion has started to evaporate.
2. Medium-breaking emulsions are used for coarse road and plant mixes, heavy plant pre-mix grades of construction; also for coarse aggregate cold patching.
3. Slow-breaking type of emulsions are used for road and plant mixes requiring about 50 percent asphaltic emulsion; also for roadside cold patching (65-70 percent asphalt); for all operations using fine aggregates and soil aggregates as in soil stabilization work. This grade of emulsion is scientifically balanced and is made especially to withstand active shovelling or mixing at the plant or on the road, and the particles of asphalt will not coalesce until after the mixing operation and the material has been tamped in place. These emulsions are fairly stable and do not "break" until the water they contain actually evaporates.

The subject of soil stabilization is comparatively new and a most important development. It refers to new characteristics imparted to a soil by what practically amounts to water-proofing the soil so that it will lose its capillary attraction for water. Besides water-proofing, such treatment of soils secures the required or increased load-carrying capacity in the subgrade upon which the wearing surface, or the asphalt pavement proper, is to be built. Subgrade soils are kept moist and are many times quite wet by the intrusion of surrounding water through soil capillarity. When damp soils are intimately mixed with an emulsion the dispersed particles of asphalt are uniformly distributed throughout the clay material; and as the emulsion "breaks" and the capillary pores of the soil become clogged, the soil particles themselves are coated with asphalt, which thus reduces capillary action toward water to a minimum.

Soil science has become a new branch of paving technology. A particularly practical discussion of basic concepts, specifications of soils, stabilizers, and the mechanics of soil stabilization is given by McLeod.[4] Researches in soil stabilization have recently been discussed by McKesson.[5]

Composition of Asphalt Emulsions

Asphalt emulsions, whether of the water-in-oil or oil-in-water type, consist of the following three components:

1. Asphalt,
2. Water,
3. Emulsifying agent, or emulsifier:
   A. Organic—This group includes water- or oil-soluble soaps, such as soaps of sulphonated petroleum, fatty oils of vegetable or animal origin, and naphthenic acids; proteins, rubber, amines, casein, procein, fatty acids and their metallic soaps; oxidized paraffine wax-acids, rosin, tannates, waste products from the paper industry, such as waste sulphite liquor, and tall-oil, and other miscellaneous materials usually in the form of soaps containing one of the other above materials.
   B. Inorganic—This group comprises alkalies, ammonia, various salts such as the silicates, phosphates, hydroxides, and colloidal material such as hydrous oxides, hydroxides, Benonite, clays, and materials of that type; Portland cement, etc.

The emulsifiers will be re-grouped later as to the types of emulsion they produce.

Commercial asphalt-in-water emulsions contain approximately 45 to 70 percent asphalt, about 1 percent of soap, the remainder being water.

Important Properties of Emulsions

We shall now discuss the above three items and the effects which the three components have on the type and properties of the emulsions enumerated

above. Inasmuch as the asphalt-in-water emulsions are the most commonly used in paving, this type of emulsion will therefore be discussed throughout this paper.

Types of Asphalts Used for Emulsification

Any good grade of steam-refined oil asphalt (residual asphalts) or natural asphalt is used in making emulsions. The material should be ductile at 77° F., and free from cokey substances, free-carbon, or carbenes. Blown asphalt may also be used where specifications permit. The penetration of the asphalts most commonly used is between 100 and 250, though there are a few cases where 40 to 90 penetration material is required.

From the point of view of the paving engineer the term "asphalt" designates merely one of the components in an asphalt emulsion, and emulsion specifications deal chiefly with the tests on the emulsion and properties of the recovered asphalt. The term "asphalt," therefore would appear to designate a single or definite engineering construction material.

Inasmuch as the stability of emulsions is highly dependent on surface phenomena having to do with physical forces in oil-water systems, the physical organic chemist must needs deal with this important component of asphalt emulsions from the viewpoint of its actual makeup, or inherent physical structure.

Bitumens consist of four empirically designated hydrocarbon groups: asphaltenes, asphaltic resins, oil resins, and the oils. The asphaltic resins and the oil resins are now commonly included under the name of "resins." Asphalt itself when it is practically a pure bitumen is a dispersion of high-molecular-weight hydrocarbons or asphaltenes; this component is of low hydrogen content and recent determinations show the molecular weight of this fraction to be approximately from 10,000 to 140,000 molecular weight.[6, 7]

The asphaltenes are dispersed by the so-called "resins," which are of intermediate molecular weight, in the external or oil phase material. All four groups may contain, besides the hydrocarbons, hydrocarbon derivatives containing oxygen, sulphur, and nitrogen in addition to carbon and hydrogen. The oxygen and sulphur are usually found in chemical combination in the high-molecular-weight asphaltenes, and to a lesser extent in the "resins." Gurwitch gives the following composition of the asphaltenes:[8]

Composition of Asphaltenes

C	.....	86	to 90	percent
H	.....	6	to 8.5	percent
S	.....	0.6	to 1.4	percent
O	.....	1.1	to 6.8	percent
N	.....	Traces		

This component is obtained from asphalts as the fraction insoluble in low-boiling petroleum ether, and thus obtained is usually a hard, brown to black colored, high melting-point brittle solid.

The above-mentioned asphaltenes existing in the continuous phase as stably dispersed particles give hardness, color and body to the bitumen. The asphaltenes are peptized by the "resins" which are adsorbed on the asphaltene particle. This two-component system, or micelle, forms a stable colloidal solution in the external or oil phase; the whole system is therefore an oleosol.[9]

The dispersed asphaltenes are found to be peptized to the greatest degree when the oil phase is rich in aromatics or hydro-aromatic hydrocarbons. We find many of the properties of asphalt emulsions will eventually be better understood, as the nature of the constituents of asphalts is correlated and connected with the rheological properties of the bitumen itself. With the oil phase pretty much of an aromatic character, we find asphalts whose flow properties follow the law of Poiseulle; as is the case with purely aromatic hydrocarbons of viscous character, we therefore find the temperature coefficient of viscosity of the asphalt to be very high; as the content of aromatic oils decreases and paraffinic type oils predominate, the asphalt shows a lower temperature coefficient of viscosity and there is also a decrease in the peptization of the asphaltenes.[10] As is well known, this change in peptization leads to increased plasticity and elasticity of the asphalt.

The effect of air-blowing transforms the aromatic hydrocarbons into "resins," and the latter are finally converted into asphaltenes—the aliphatic oily hydrocarbons not being oxidized to that end product in the initial stages. As obtained by vacuum or steam distillation high grade oil asphalts are practically non-plastic. Air-blowing produces plastic material as well as some increase in saponifiable constituents which in themselves have an effect on emulsifying properties. The inherent structure of an asphalt alluded to above has a profound effect on its properties such as viscosity of structure, temperature susceptibility, ductility, plasticity, brittleness, etc.; these properties are dependent on the relative percentages of each of the three components and the degree of peptization of the asphaltenes—as found in the asphalt—so that we have to deal here also with quantitative variables.

Thus it is seen that asphalt itself is a colloidal system, and its properties effect the properties of the emulsion. The character of the asphalt film deposited by the emulsion determines in the end the durability and life of the finished pavement. Since the earlier work of Nellensteyn at Delft, Holland, on the fundamental concepts of the structure of asphalts,[11] and later the physical researches of Wilhelmi,[12] as well as the excellent work of the Danish and British Road Research Laboratories, a greater volume of much excellent work has recently been carried out in the United States on the properties and constituents of asphalts.[13]

Asphaltic petroleum distillation-residues often contain, besides combined sulphur, compounds containing combined oxygen in carboxyl form, such as organic acids or naphthenic acids. They are not an inherent part of the four arbitrarily designated asphaltic constituents mentioned above. The naphthenic acids exist as impurities in crude oils and are present in asphalts as high-boiling, acidic compounds. These acids are important from the standpoint that they effect the quantity and type of emulsifier and also other properties of the finished emulsion, such as stability, for instance.

The type and quantity of stabilizer or emulsifier used is dependent, to some extent, upon the acidity of the bitumen and on the content of combined resins plus asphaltenes. If the acid content is low the bitumen is inactive and is not self-emulsifying; often additional oil acids are added to increase the stability of the emulsion.

The molecular weight of the added oil-acids (naphthenic acids) has been found to be important—the low-molecular-weight naphthenic acids having been found to be better emulsifiers, when soap is used,

than the high-molecular-weight acids which are better stabilizers at equal concentrations of sodium hydroxide.[14]

Other impurities which may be present are inorganic salts in small amounts, including iron and vanadium oxides and impurities of that nature. Unless the content of these impurities is large, that is, over 0.5 percent, they usually do not interfere with the emulsifying properties of the emulsifier.

Concerning the second component, or the water which is used in emulsions, it can be said that soft water should be used when possible; otherwise manufacturing allowances are made for the hardness of natural waters.

In discussing the third item, namely the emulsifier, considerable importance must be given to this component, since the nature of this component determines, to a great extent, the kind of emulsion that can be obtained, its stability and lability. The emulsifiers can be grouped under two headings:

1. The commonly employed emulsifiers are oil- or water-soluble substances, typified by the soaps of monovalent metals. These emulsifiers act as such due to their property of lowering the surface tension of either the asphalt or the water. The general rule has been that when the soap is more soluble in water than in the asphalt, such as sodium oleate, an asphalt-in-water emulsion is formed; if the emulsifier is more soluble in the asphalt, such as calcium or magnesium oleate, a water-in-asphalt emulsion most generally forms; it has also been found that the component most completely wetting the compound, or emulsifier, will be the external phase in the emulsion. The solubility rule is a good rule to follow, though it probably has many exceptions.

The physico-chemical basis which underlies the action of oil- or water-soluble emulsifiers is the oriented wedge theory—namely, the oil-soluble hydrocarbon tail of the emulsifier molecule extending into the asphalt phase; the monovalent positive ion of the emulsifier molecule, being water-soluble, is said to extend into the aqueous phase.

One cannot say that all sodium soaps are emulsifiers for only asphalt-in-water emulsions, since the nature of the anionic part of the soap molecule has a bearing on its solubility. For instance, the sodium soap of the highly oil-soluble phenylstearic acid is oil-soluble, to some extent, as well as quite water-soluble. The type of emulsion that can be obtained is also governed by secondary qualifications, such as very often the percent of each phase which is present, and sometimes by the method used in preparing the emulsion.

Emulsions containing soaps and emulsions of this group usually "break" readily when in contact with most soluble salts, mineral powders, stone, and foreign material that effect the electrical charges of the dispersed particles, which causes these emulsions to become unstable. This occurs generally before the water has begun to evaporate, once the emulsion has been applied.

2. The second type of emulsifying-materials is that which is either wetted by one component more than the other, is practically insoluble, or only slightly soluble, in both phases, effects the surface tension only slightly, and forms plastic adsorbed films on the dispersed asphalt particle, or around the water particle, due to peptization and swelling.[15]

Under this group we find the materials most commonly used to be colloidal clays, such as Bentonite, various oxides, silicates, Portland cement, ground slag, certain salts of the heavy metals, etc. Emulsions formed with these types of materials show greater stability than those containing emulsifiers of the first group, are known to "break" at a much slower rate, and then only mostly when the water in the emulsion has begun to evaporate.

Emulsions containing the second group of emulsifiers are not sensitive to the presence of foreign substances, dissolved salts, and changes in the electrical charges of the dispersed particles do not cause the emulsion to "break." This type of emulsifier produces, with or without soaps, "slow break" emulsions which are quite stable.

The second type of emulsifiers, insoluble in water and often insoluble in asphalt, function due to their wettability by one or both of the phases. The idea of wettability also underlies the action of Group One emulsifiers. This concept is probably the true yardstick to employ in order to determine the type of emulsion that can be obtained, rather than the use of the general solubility rule. Recent use of additives for bitumens, such as increasing the adhesivity of asphalts for mineral aggregates of acidic or alkaline structure, is a logical development of the application of wettability, as well as detergency, in asphalts.

It must not be construed from the above that either type of emulsion can contain only Group One or Group Two emulsifiers. Very often both groups of emulsifiers are used in the same emulsion, combining the useful qualities of each group for specific purposes. For example, "fast-breaking" emulsions, exhibiting excellent storage stability, contain both a soap (of a petroleum derivative) and metallic hydroxides produced inherently as the stabilizer.[16]

Again, very "slow-breaking" emulsions can be produced by first forming a "fast-break" emulsion, stabilizing thereafter with an organic agent to produce a "slow-break" emulsion, and adding to the stabilized emulsion a small amount of colloidal clay to increase storage stability.[17]

Asphaltenes themselves have been discovered to be good emulsifiers, and propane-precipitated asphaltenes, by addition to poor emulsifying asphalts, are said to produce "self-emulsifying asphalts," which require only a stabilizer to produce either a "fast" or "slow-break" emulsion.[18] Addition of asphaltenes to the asphalt prior to making the emulsion is said to increase very greatly the storage stability of both types of emulsions.[19]

Storage-Stability

We have enumerated the general specifications and qualities of the three components of an emulsion. It is desirable at this point to list some of the properties which emulsions exhibit and what the desirable requirements are.

Assuming the emulsion has been properly made and contains the correct amount of asphalt of given specifications, the prime requisite or characteristic is that emulsions show stability on storage, and the ability to "break" (lability), or deposit the dispersed asphalt as films of adhesive material on the mineral aggregate within certain time periods. These contradictory requirements must be present in well-made commercial emulsions. Good commercial emulsions today are made which are storage-stable and "fast-breaking."

Stability and liability are almost entirely dependent on:

1. The particle size of the dispersed asphalt, and
2. The pH value of the aqueous or emulsion phase.

Particle size and pH values are inter-related and

are the prime factors governing and determining the limits within which emulsions are stable. The ability for an asphalt to be emulsifiable depends on the tension between the bitumen and the aqueous phase, and also on the concentration of active substances present at the interface. Active substances, or emulsifiers, are usually present in the asphalt itself; this activity resides in the material composed of the "resin-asphaltene" micelle. Also included among the active substances are acidic compounds, such as the naphthenic acids; the added emulsifier itself, of course, is the main source of so-called active substances which are present at the interface between asphalt and water.

The activity of substances adsorbed at the interface between asphalt and water, or oil and water, is shown by a lowering of interfacial tension values. Petroleum resins and petroleum soaps, for instance, will considerably lower these values, as determined by Gurwitch:[20]

Table Showing Surface Tension of Petroleum Products Against Water

Paraffinum liquidum .....47.2 dynes.
Paraffinum liquidum + 1% naphthene soaps .....30.5 dynes.
Paraffinum liquidum + 3% of petroleum resins...40.1 dynes.

The tension at the interface, or interfacial tension, is known to decrease with an increase in the pH for different substances. The following table shows relative values of interfacial tensions in relation to pH, for Panuco (Mexican) asphalt, commercial oleic acid, and tall oil, as determined by Radulesco:[21]

TABLE 1

pH	Panuco Asphalt*	Commercial Oleic Acid	Tall Oil
2	23 (Dynes per cm.)	18 (Dynes per cm.)	16 (Dynes per cm.)
4	26	20.5	17.5
6	27.5	19.5	15.0
8	26	12.0	8.5
10	20	5.0 at 9 pH	3.0 at 9 pH
12	0	0.0 at 9.5	—

* Pen. 77 F., 191.

The tension determinations were made with a Du Nuoy apparatus,[22] using 0.5 percent of the material to be tested dissolved in benzol; determinations of pH values were made with Clark-Lub Universal Buffer.

The effect of adding additives such as oleic acid and tall oil is best brought out by Table 2, which shows the limit of stability or emulsifiability for Panuco asphalt:[21]

TABLE 2

pH Limits of Stability for Panuco Asphalt Emulsions

Emulsion made with:	pH
1. Caustic soda only*	10.6 - 12.5
2. 0.9% oleic added (plus alkali)	8.1 - 12.7
3. 3% tall oil added (plus alkali)	8.4 - 12.8

* See Figure 2.

As shown in Table 1, certain relations between interfacial tension and pH value exist for each substance which may be added to asphalts; furthermore, it has been found that, between certain pH limits of an emulsion, particle size is at a minimum.[23] For instance, pH values determined in emulsions of two asphalts indicate that the smallest average size of the dispersed particle (based on the average diameter of the particles) is between pH of 11.6 and 11.9 at 2.1 microns for a Panuco asphalt, and that the smallest particle size observed for Colombian asphalt was only 2.6 microns, at a minimum at 12.5 pH, using in both cases only caustic soda as the emulsifier.

For the Panuco asphalt at a particle size of 3 microns average, the limits of pH were 11 to 12.2, and for Colombian asphalt between 12.1 and 12.6.[21] It can be seen that the Panuco asphalt shows a wider range of pH with the smallest particle average diameter size and is therefore the easier to emulsify. This is an important determination to make on asphalts which are to be emulsified prior to preparing commercial emulsions on the large scale.

If, to the Panuco asphalt, 3 percent of a commercial oleic acid of 95 percent purity is added a lowering of interfacial tension results at lower pH values, as would be expected. The quantitative relations are brought out as shown in Figure 1. This graph correlates pH, interfacial tension, and the average diameter of the particles of dispersed asphalt using caustic soda to make emulsions A′ and B′.[21]

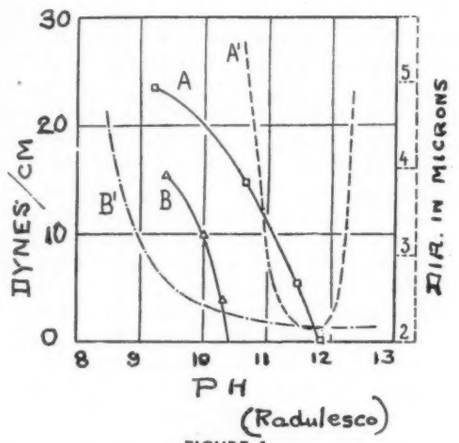

FIGURE 1

Relation between interfacial tension and limits of stability. A, interfacial tension of Panuco asphalt alone; B, interfacial tension of same with addition of 3% oleic acid; A′ and B′ are corresponding limits of stability of caustic soda emulsions of A and B.

Such quantitative relations as those shown for Panuco asphalt should furnish valuable data useful in similar studies of new or unknown asphalts with or without added emulsifiers.

Particle size has an important bearing on the storage-stability of emulsions and on the phenomena of sedimentation. The arithmetic mean diameter of the dispersed particles in good commercial emulsions is usually 3 microns or less as determined from size frequency curves. In studying the storage-stabilty of emulsions it has been found that, under constant conditions and quiescent storage, with an increase in the average particle size, a small but definite amount of asphalt will tend to settle out of the emulsion. The rate of settling has been found to be related to particle size which varies from maximum to minimum to maximum within pH ranges of 10.6 to 12.5 in the case of Mexican asphalt. If one uses as a rate of settle, for instance, the number of mm. of asphalt

settling per day, a curve (designated by hollow circles) is obtained as shown in Figure 2.[21]

In Figure 2 the surface tension and stability limits of the emulsion in the presence of sodium chloride is included. The sodium chloride solution use is 0.1 normal in cc.'s for 10 cc.'s of emulsions. Many salts, such as sodium chloride, aluminum chloride, magnesium sulphate, barium chloride, and salts of univalent ions actually improve the stability of emulsions up to certain concentrations, and beyond these concentrations these salts are known to be strong flocculating agents.[24]

There are secondary factors besides the above-mentioned particle size effects which will determine the rate of settle or sedimentation of the emulsion; these are viscosity, heat, cold, and especially the presence of materials or solutions containing salts or other electrolytes. The presence in the storage tank of obnoxious gases, and even carbon dioxide in the air, will disturb pH values sufficiently in the long run to upset the equilibrium of asphalt emulsmallest particle size possible. Emulsions should be free from coarse particles, such as particles above 10 microns in diameter. Otherwise they may cause clogging of spray nozzles, pressure hose, and other road building equipment. Where emulsions contain coarse particles present in only small amounts they can be screened prior to use. A size frequency curve as discussed above is valuable in determining the composition or homogeneity of the dispersed phase.

Lability

Lability, or the ease with which an emulsion will "break" or deposit the dispersed asphalt is probably the most important characteristic which is required of an emulsion next to its ability to be stable on storage. The suitability of asphalt emulsions is governed by the speed with which it "breaks" and deposits the dispersed asphalt as a uniform film on the stone aggregate. Rather complicated physico-chemico phenomena appear to underlie the phenomenon of "breakability." It is true that in the stable type

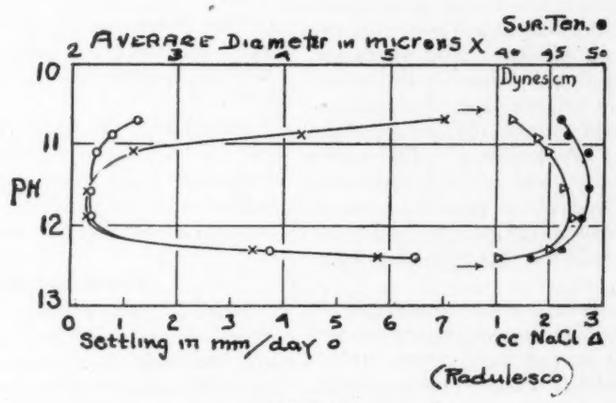

FIGURE 2

Limits of stability of Panuco emulsions with sodium hydroxide (no emulsifier) showing particle size, settling per day, and surface tension with and without sodium chloride in relation to pH value.

sions. The phenomenon of sedimentation caused by a "packing effect" of the dispersed phase in asphalt emulsions has been investigated by Gabriel.[25]

Concerning stability on storage it has been found that for Panuco and Colombian asphalt with or without emulsifiers, the storage stability will be greater than 100 days (upward to 400 days) when the average diameter of the particles in microns is below 2.5. At a diameter above 2.5 the stability rapidly drops off to 75 days at 2.5, to 30 days at 3 microns, and 20 days for average diameter of 4 microns and above.[21]

Valuable data is obtained indicating or predicting the stability of an emulsion when size-frequency curves are made at various time intervals, and tabulating the percentage of increase of coarse particles as they make their appearance with increase in time.

Besides stability on storage an important property of good emulsions is that of uniformity or homogeneous distribution of dispersed asphalt of the

of emulsions, such as those containing colloidal clay, the evaporation of the water appears to be the determining factor in lability. The emulsion will become unstable as soon as a certain maximum concentration of asphalt is reached beyond which the dispersed phase cannot exist as such but coagulates. However, the ease of the breakability of emulsions made, for instance, with alkaline soaps, will diminish as the pH increases up to certain values. For a given aggregate the optimum value of pH, at point of break, depends entirely on the nature and the quantity of the emulsifier.

For the same emulsifier lability is also a function of average size or diameter of the particles. The property of emulsions to "break" is greatly influenced by the nature and proportion of salts present in the water. The nature of the bitumen plays a very important role through the intermediate action of the resins and asphaltenes that compose it, and which also determine the equilibrium of the emulsion. The

lability of soap emulsions can be determined by the pH and quantity of the emulsifier. In looking for uniformity of relations between these physical properties it must be borne in mind that a relation can be looked for only in emulsions which have been prepared from the same type of asphalt, soap, water and under very exact similar conditions.

The nature of the adsorbed film, especially its thickness and the positions in which the polar and non-polar parts of the emulsifier molecule are orientated at the surface of the interface have also an important bearing on lability. A great deal of research work on the nature of interfacial films has been done in recent years. Many investigators regard the protective film of emulsifier on the asphalt particle to be monomolecular;[26] however, McBain[27] claims the adsorbed layers to be more than one molecule thick.

Nonaka,[28] Mathews and Stamn[29] have found values of the adsorbed layer which indicate that the layer is of polymolecular thickness. Recent work done along these lines further indicates that the concentration of active substances on the surface of the asphalt particles is about ten times greater than that necessary for a monomolecular layer.[21]

Absorption of active substances on and at surfaces to which the emulsion is applied appears to be the underlying phenomenon of lability. For instance, Weber and Bechler claim that various solid materials absorb alkali.[30] It was shown that the preliminary treatment of stone aggregates by an alkaline solution actually delayed "breakability." The same occurs when the aggregate has been wetted with soap solution. Apparently the "break" of the emulsion is due to a lessening of the percentage of the emulsifier in the emulsion which tends to destroy the equilibrium of the system.

A decrease in the concentration of alkali caused by absorption on the surface of the aggregate lowers the concentration of alkali in the bulk of the emulsion. Basic aggregates of which basalt is an example, are known to be very surface-active, while siliceous stones, such as quartzite, appear to be inert.[31] Mack, for instance, points out that interfacial energies of bitumens themselves against silica show positive values, while against limestone negative interfacial energy values are obtained.[32]

Secondary factors also influence the property of lability besides preferential absorption of the soap; these are the presence of soluble salts, surface area of the stone intended to be coated, evaporation phenomena, mechanical disturbance, atmospheric conditions, etc. Brig. Gen. E. G. Wace (Great Britain) has given an excellent resume of stability and lability, and their evaluation.[33] There are electrical forces residing on the dispersed asphalt globules and at the oil-water boundary, and one speaks of a contact potential and the tendency to rupture occurs when this potential decreases. A critical point exceeding 0.03 volts is said to produce stable emulsions.[34]

Electrical methods to determine rupture or lability are complicated to perform and are based on determining the critical electrical charge present on the dispersed particles at the moment of flocculation.[35] Methods to determine lability have evolved through the use of various procedures, many of which are dependent on actually using material similar to the aggregate to be coated as the precipitating agent. Some investigators actually contact the emulsion with oblong pieces of basalt and determine the absorbed bitumen thus deposited after "break."[36] Klinkman measures a so-called stability number, using the soluble constituents from various aggregates as precipitants for the dispersed phase.[37] The Myers Test employs solutions of calcium chloride as the precipitating electrolyte.[38] Weber and Bechler,[39] and Weber use various types of stones and determine the amount of bitumen precipitated on it.[40]

Rapid and practical methods to determine lability for use by asphalt research chemists and highway engineers have been formulated which give valuable information of practical nature. These methods will be discussed below under "Testing Methods."

Tests and Methods of Testing

Before enumerating the practical physical and chemical tests carried out on asphalt emulsions there are methods to determine the properties which we have discussed above, which methods are not ordinarily included in routine laboratory or service tests. They are the determination of pH value, surface tension, average diameter of dispersed particles (the so-called "particle-size" determination), and size-frequency curves. Determinations of this kind are essential to the proper study of asphalt emulsions.

The pH value is best determined using an iridium

TABLE 3

Specifications for Emulsified Asphalts
(Adopted September 11, 1940)

Specification Designation	Rapid Setting	Medium Setting			Slow Setting	
	RS-1	MS-1	MS-2	MS-3	SS-1	SS-2
Tests on Emulsion:						
Viscosity, Furol 77° F., sec	20–100	20–100	100+	.....	20–100	20–100
Residue by Distillation	55+	55+	60+	65+	55+	55+
Settlement, 5 days	—3	—5	—5	.....	—3	—3
Demulsibility (a) 35 c. c. N/50 $CaCl_2$	60+	.....	.....	.....	.....	.....
(b) 50 c. c. N/10 $CaCl_2$	.....	—30	—30	.....	1.0—	1.0—
Sieve Test—Ret. on 20 Mesh	—0.10	—0.10	—0.10	—0.10	—0.10	—0.10
Miscibility, 2 hrs	.....	Pass	Pass	Pass	Pass	Pass
Stone Coating (3 min.)	.....	Pass	Pass	Pass	.....	.....
Cement Mixing, Percent Max	.....	.....	.....	.....	2.0—	2.0—
Tests on Residue:						
Penetration 77° F., 100 g., 5 sec	100–200	100–200	100–200	100–200	100–200	40–90
Soluble in CS_2 (Pet. Asphalt) Percent	97.5+	97.5+	97.5+	97.5+	97.5+	97.5+
Soluble in CS_2 (Nat. Asphalt) Percent	95.0+	95.0+	95.0+	95.0+	95.0+	95.0+
Ash	—2.0	—2.0	—2.0	—2.0	—2.0	—2.0
Ductility 77° F., cm	40+	40+	40+	40+	40+	40+

TABLE 4

Specifications for "Slow-break" Asphalt Emulsions (Mixing Type Emulsions)

To remain at constant viscosity for 30 days, the emulsion may or may not withstand freezing.

Viscosity Furol 77F	40-80 sec.
Residue:	
Pen. 77F	70-100
CCl_4 Sol.	95% or over
Duct. 77F	60 cm. +
Sp. Gr. 77/77F	1.00+
Residue by dist'n	55-60%
(a) Oil portions of distillate to 500 F. (vol.)	0.5% or less
Sieve test	0.05% or less
Miscibility 2 hrs.	Pass
Demulsibility (50cc N/10 $CaCl_2$)	5 or less
Settlement 10 days	3 or less
Mixing	2% max. broken
Dehydration	0.6 or over
Total combined amount of saponifiable substances, including petroleum acids[45]	0.75% or less

electrode[41] or any of the modern types of Beckman pH-value apparatus. Surface tension and interfacial tension determinations are usually carried out with a tensionmeter such as the Du Nuoy apparatus,[22,42] and calculations made according to the standard methods of physical chemistry. The method for determining the average diameter of the dispersed particles, or so-called "particle size," can be that of actually counting the dispersed particles of the emulsion at a magnification of about 300, using a standard Thoma type haemocytometer cell.[43] A more rapid and perhaps more exact method to determine the particle size is that of using a spectrophotometer and employing the following formula:[21]

$$dm = \frac{6.14}{K} + 1.23$$

where, dm = average diameter in microns,
and K = the extinction coefficient.

Knowing the particle-size the size-frequency curve for the emulsion is calculated and plotted.[43] The size-frequency curve is a curve which shows the composition of the dispersed asphalt particles in terms of their various diameters in microns, and from which can be calculated the average mean diameter of the asphalt particles.

For routine testing the physico-chemical properties of emulsions we have been discussing are evaluated by a series of practical methods used by highway engineers and asphalt chemists. Service and laboratory tests are constantly being improved as to technique and aligned with the principles of physical chemistry.

The usual tests are those performed on the emulsion itself, such as viscosity, sieve test, stone coating, etc., and those tests made on the asphaltic residue obtained from the emulsion, such as penetration, ductility, and solubility.

Given in Table 3 are Standard Specifications for Emulsified Asphalt, formulated by the Asphalt Institute and adopted in 1940.[44] By way of an example showing the characteristics there is given in Table 4 the tests and requirements of an emulsion suitable for use in the "mixing method" of paving construction. Test methods described in these specifications are those of the A.S.T.M., standard method—D244-39, and Bulletin 101, December, 1939 (A.S.T.M.). Standard methods for testing asphalt emulsions are also given by the American Association of State Highway Officials, 1938.

Many of the properties and characteristics of asphalt paving emulsions that have been briefly described are also those of emulsions in general. Their study has enabled the many investigators in this field of applied colloid and surface chemistry to improve our materials of engineering construction. New and valuable compositions of matter and improved techniques have resulted from such research work; this is already evidenced by the recent and widespread use of asphalt additives, the application of new principles in soil science, and improved methods of modern paving construction for better military and civilian roads and airports of the future.

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Multicomponent Distillation

A New Graphical Method of Solution

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THIS paper presents a new graphical method for the stepwise calculation of multicomponent distillation problems, which, with the aid of Shiah's K-chart, uses a single curve to represent the equilibrium curve for all the components. Uses also are made of both Hibshman and Robinson and Gilliland's technique to obtain the concentration of each component as well as the temperature on any plate with practically no trial-and-error work.

NUMEROUS methods have been proposed for the solution of multicomponent distillation problems. Outstanding contributors along this line are Brown,[1] Fenske,[2] Gilliland,[3] Lewis,[6] Underwood,[10] etc. A critical review of the various proposed methods up to 1935 was presented by Gilliland,[3] who pointed out that of all these methods, that of Lewis and Matheson[6] is "the most fundamental and general in application." Nelson[7] proposed a method for expressing the concentration of any component on any plate in terms of a known concentration of the same component on a given plate. The equations are somewhat involved and their application necessitates the estimation of the temperatures on all the plates. This method would find more use in checking operating data rather than for design calculations. In Robinson and Gilliland's[8] modification of Lewis and Matheson's method, use is made of the relation, $y = Kx/\Sigma Kx$ during the stepwise plate-to-plate calculation to eliminate a large amount of trial-and-error work required for adjusting the values of Kx's to add up to exact unity. The disadvantage of this simplification lies in the fact that the temperature on each plate is not known even after the complete solution of the problem. Hibshman[5] simplified Lewis and Matheson's method by plotting a seris of equilibrium lines for all the components on a single sheet of graph paper. For systems consisted of a large number of components and/or for those cases where some of the components are very close in volatility, the chart produced would be crowded with curves to an extent that its use become rather inconvenient. This paper presents a new graphical method for stepwise calculation, which, by the aid of Shiah's[9] vapor-liquid equilibrium constant chart, uses a single curve to represent the equilibrium lines for all the components involved. Both Robinson and Gilliland's[8] and Hibshman's technique are also used in obtaining the concentration of each component on each plate as well as the temperatures on each plate with practically no trial-and-error work.

The Method

Fundamentally, the procedure for the estimation of number of theoretical plates involved for the continuous separation of a multicomponent mixture is exactly the same as those given for binary mixtures; i.e., starting with the composition of the liquid at any position in the tower, the vapor in equilibrium with this liquid is calculated; and then by applying the appropriate operating equations for the section of the tower in question to each component, the liquid composition on the plate above is determined and the operation repeated from plate to plate up the column. The procedure can also be reversed to obtain the composition and temperature of each plate from the top down. Usually the calculations are started from both directions, namely, from both still and top plate or distillate, to be matched together at the feed plate. To estimate the vapor in equilibrium with a given liquid at a known pressure, is a simple matter in the case of binary mixtures. In the case of multicomponent mixtures, a trial-and-error calculation is necessary. As the temperature of the plate is not known, a value is first assumed and the various equilibrium constants at the known pressure and assumed temperature are read off from tables or charts and the vapor composition calculated. If the sum of the mol fractions of all the components in the vapor, so calculated add up to 1, the assumed temperature is correct, otherwise the procedure must be repeated until the sum is unity. Recently, Shiah[9] presented a single chart to represent all values of equilibrium constants for methane up to octane and higher. This chart is quite an improved form of presentation of data. Thus, with a series of the so-called "equal K lines" plotted on the right hand side of the chart, the K curves for the chosen reference compound namely, n-pentane, on the left hand side of the chart serves to represent the values of K's for all hydrocarbons. In as much as in an ordinary multicomponent distillation problem, the operating pressure is usually known or can be easily calculated, a single K curve for n-pentane at the pressure in question instead of the series of curves covering a wide pressure range can be plotted on the left hand side of the chart to represent the equilibrium constants for all hydrocarbons at all temperatures. This is shown by the heavy solid curve in Figure 1. Thus a vertical line drawn through the assumed temperature reading cuts the series of "equal K lines" at various points. From this various points of intersection, horizontal lines are drawn, which cut the K-curve for n-pentane at the given pressure at various points. These points

Multicomponent Distillation

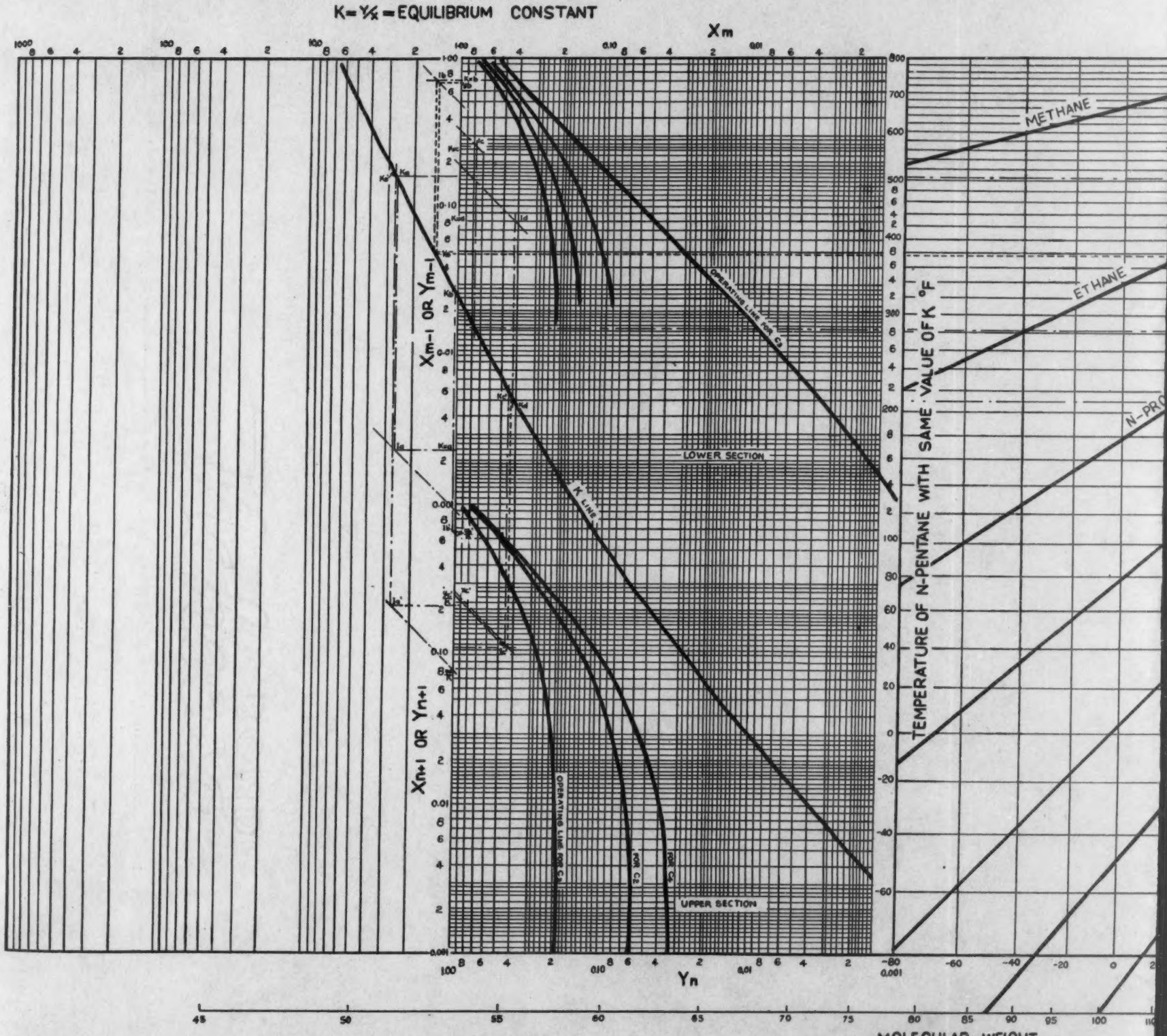

FIGURE 1

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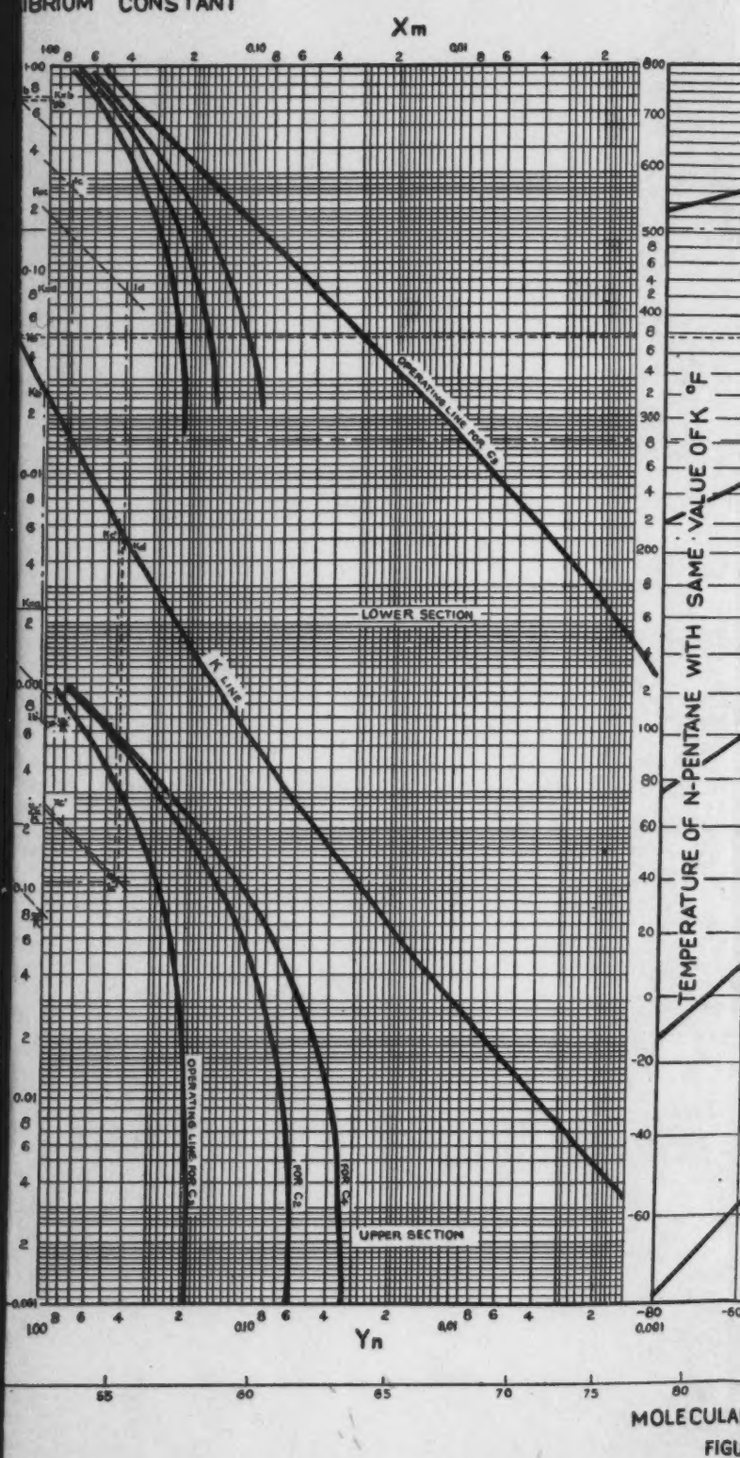

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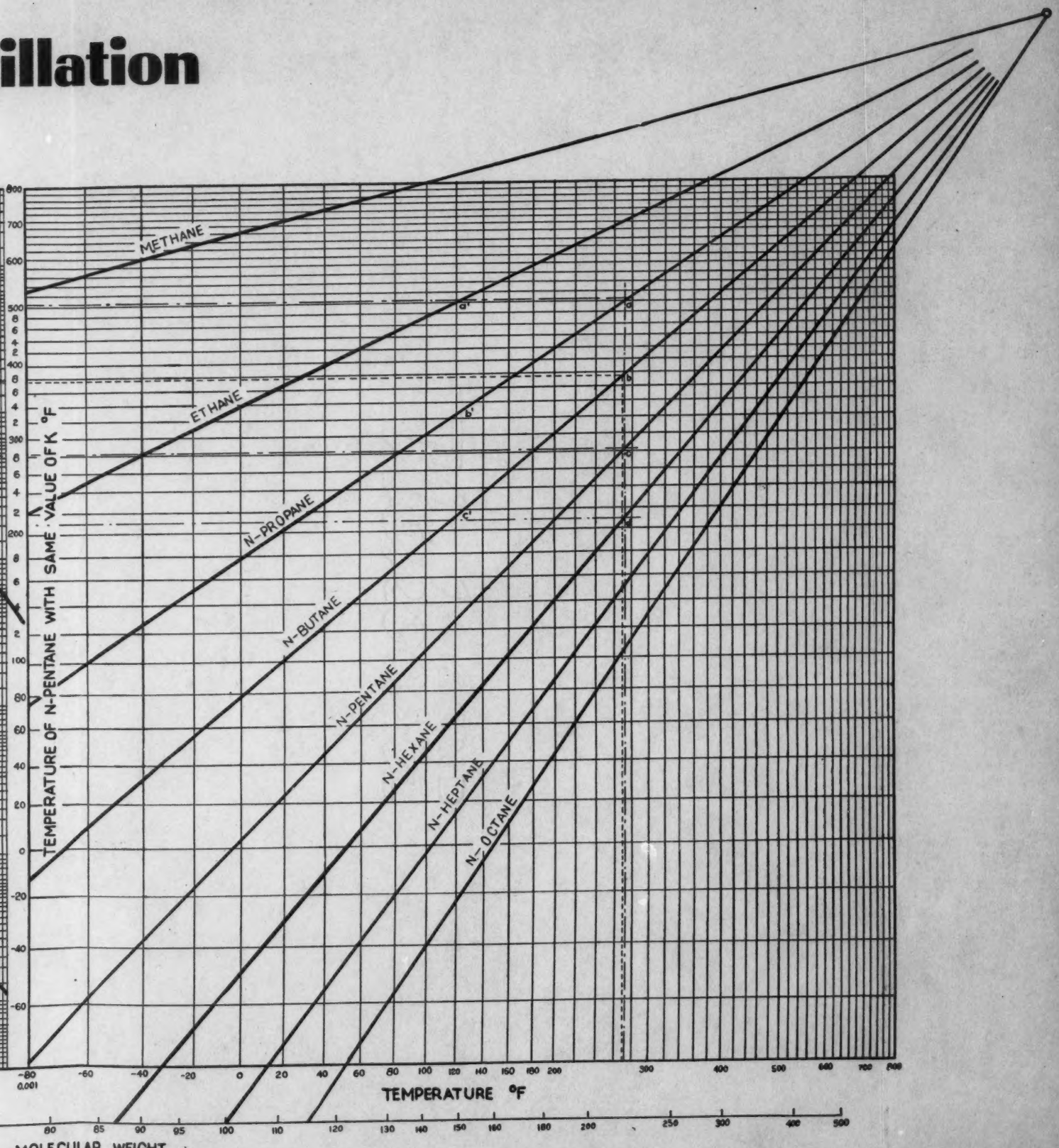
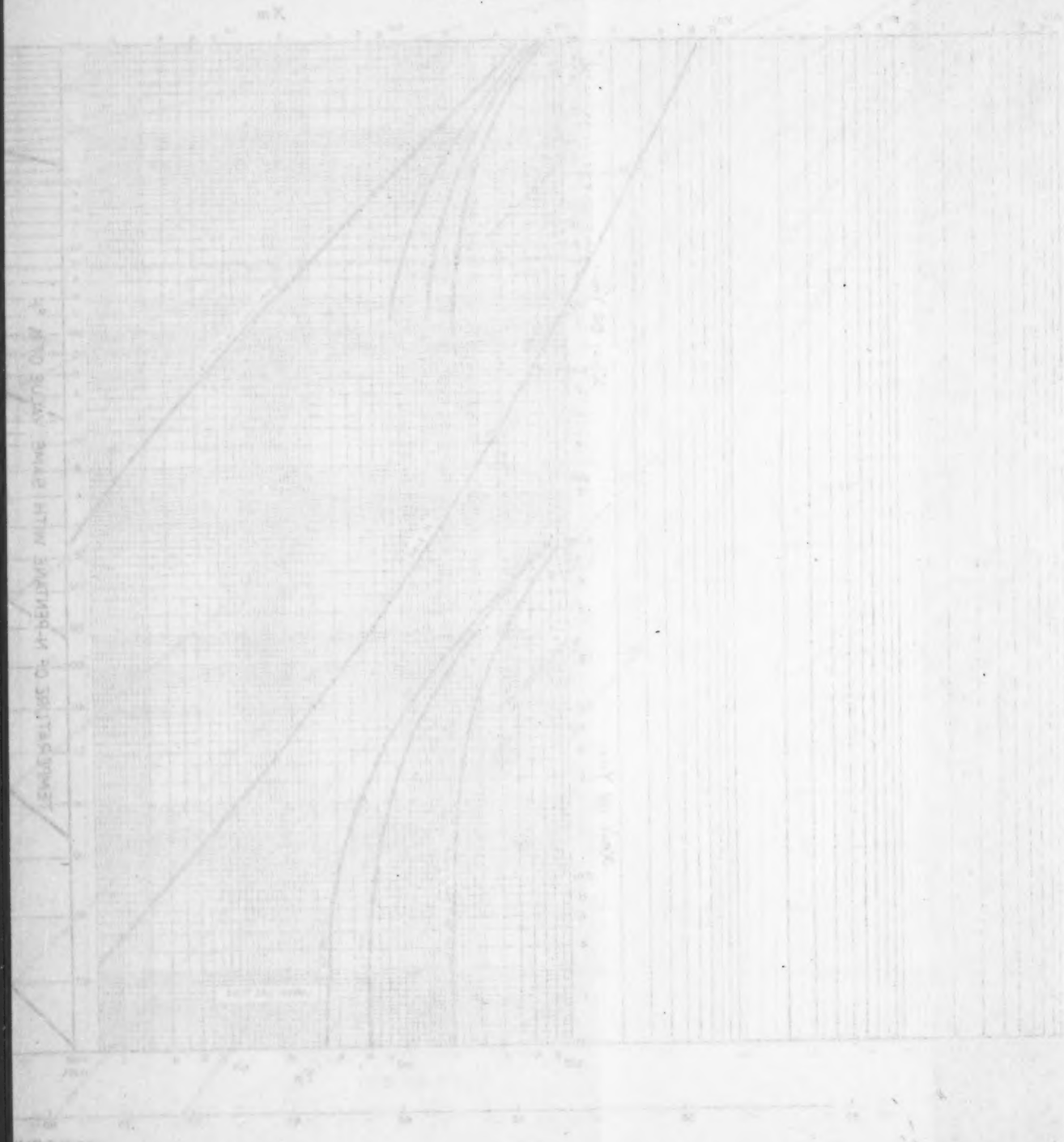


FIGURE 1



give the value of K's at the given pressure and assumed temperature directly. It can be seen from Figure 1 that the position of the K curve as reproduced from Shiah's K chart, is fixed with regard to the "equal K lines" on the right hand side of the chart and the abscissa on the left hand side of the chart representing the value of K's. A part of the same abscissa can also be conveniently taken to represent x_m or y_n. The ordinate on the left hand side are divided into two halves representing x_{m-1} or y_{m-1} and x_{n+1} or y_{n+1} respectively. Thus the operating lines for both upper and lower section of the column can be plotted each in their designated space. Thus we have all the operating lines, and a single curve representing all of the equilibrium curves for the systems all compiled together on a single chart. The solution of the problem is thus much simplified. Further advantages are taken from the fact that in a log-log plotting, as was pointed out by Hibshman,[5] multiplication or division can be easily manipulated by addition or substraction. Thus, if a vertical line is drawn through a point corresponding to a value of K at a given temperature and another line drawn parallel to a straight line passing through points (1, 1) and (0.1, 0.1), and through a given value of x on the vertical scale (horizontal value of this point = 1), the intersection of these two lines when read on the vertical scale will give the value of Kx. If the assumed value of temperature is correct, the values of Kx's will add up to unity. If the sum is too far off, which is, however, very seldom the case, a new assumption of temperature has to be made. If the summation is not very far off from 1, say within 10 percent, however, Robinson and Gilliland's[8] technique can be used. Thus $y = Kx/\Sigma Kx$. The value of y's so obtained can be safely taken as the correct values. With these values thus obtained, it is a simple matter to reverse the above mentioned procedure to locate the correct temperature. Values of x's can of course be read off directly from the operating lines. As the temperature gradient between adjacent plates is usually not very large, the corrected temperature for the first plate can be conveniently used as the first assumed temperature for the next plate. The same technique as mentioned above is repeated and the values of Kx's read off. The correct value of y's are again obtained from $Kx/\Sigma Kx$ and the correct temperature value traced back from one or more of these values. Thus trial-and-error work is practically eliminated.

Going from the top of the column downward, the manipulation is similar, only it is reversed. From values of x_m's, y_{m-1}'s are read off from the operating lines. A temperature value for plate m—1 is assumed and the corresponding K's for the components located. A vertical line is drawn through a point representing a certain value of K, and a horizontal line is drawn through the point m_{m-1} on the vertical axis. From the point of intersection of these two lines, a line parallel to the straight line passing through points (1, 1) and (0.001, 0.001) is drawn. The intersection of this line with the vertical axis (horizontal value = 1) will be the value of y/K. To obtain the correct value of x, the following relationship is used:

$$x = \frac{y/K}{\Sigma y/K}$$

From the correct value of x, correct value of K, and subsequently the correct temperature are determined. Again from values of x's thus obtained, values of y's on the next plate can be read off from the operating lines and the whole procedure repeated.

Illustrative Example

The comprehensive test data on a commercial high-pressure-distillation column used for the stabilization of absorption naphtha[4] is taken for illustration. The set-up of the problem is shown in Figure 2. For simplicity, the Murphree plate efficiency was taken as 100 percent, and ordinary operating line equations instead of those involves the use of individual Murphree efficiency as put forth by Gunness[4] are used:

Above feed

$$(y_{c_2})_n = 0.72\,(x_{c_2})_{n+1} + 0.0588$$
$$(y_{c_3})_n = 0.72\,(x_{c_3})_{n+1} + 0.1895$$
$$(y_{c_4})_n = 0.72\,(x_{c_4})_{n+1} + 0.0316$$

Below feed

$$(y_{c_3})_m = 1.71\,(x_{c_3})_{m+1} - 0.0006$$
$$(y_{c_4})_m = 1.71\,(x_{c_4})_{m+1} - 0.342$$
$$(y_{c_5})_m = 1.71\,(x_{c_5})_{m+1} - 0.235$$
$$(y_{c_6})_m = 1.71\,(x_{c_6})_{m+1} - 0.133$$

These equations are plotted on the left side of Figure 1. K for n-pentane at $\pi = 18$ atm. is also plotted. As the detailed analysis of the composition of different fraction such as "propanes" and "butanes" is not known, each fraction is taken as a pure compound; thus n-propane for "propanes" and n-butane for "butanes," etc. The value of K's so obtained differ somewhat from the weighed average value used by Gunness in his algebraic calculation. However, the error so introduced is very small as the values of K's for different hydrocarbons were, up to the present, only approximate figures, such refinement as was used by Gunness is unwarranted.

Starting with an assumed still temperature, $T_w = 270°$ F. A vertical line T = 270 is drawn on the right side of Figure 1, which cut the "equal K lines" for c_3, c_4, c_5, and c_6 at a, b, c, d, respectively. From points a, b, c, and d, horizontal lines are drawn which cut the K curve on the left side of the chart at K_a, K_b, K_c and K_d respectively. From these points, vertical lines are drawn. Values of x_w's are read off on the vertical scale and a line parallel to x = y is drawn through each point. These lines cut the vertical lines drawn from K_a, K_b, K_c and K_d at points I_a, I_b, I_c and I_d respectively. Horizontal lines are drawn through these points to give the value of $(Kx_{c_3})_w$, $(Kx_{c_4})_w$, $(Kx_{c_5})_w$ and $(Kx_{c_6})_w$ on the vertical axis respectively. Thus

$$(Kx_{c_3})_w = 0.0024$$
$$(Kx_{c_4})_w = 0.705$$
$$(Kx_{c_5})_w = 0.266$$
$$(Kx_{c_6})_w = 0.08$$
$$\Sigma(Kx)_w = 1.0534$$

$$\therefore \quad (y_{c_3})_w = \frac{(Kx_{c_3})_w}{\Sigma(Kx)_w} = \frac{0.0024}{1.0534} = .002 \text{ (test data} = .007)$$

$$(y_{c_4})_w = 0.670 \text{ (test data} = 0.639)$$
$$(y_{c_5})_w = 0.253 \text{ (test data} = 0.292)$$
$$(y_{c_6})_w = 0.076 \text{ (test data} = 0.0624)$$

Starting from the corrected value of $(y_{c_4})_w$, the correct temperature is traced back along the dotted lines, Thus

$T_w = 268°$F. (From algebraic calculation $T_w = 268°$F.)
From test data $T_w = 275.5°$F.

From the operating lines, the values of x_1's are read off as follows:

$(x_{c_3})_1 = 0.0016$ (.0023 from algebraic calculation)
$(x_{c_4})_1 = 0.59$ (0.625 from algebraic calculation)
$(x_{c_5})_1 = 0.295$ (0.27 from algebraic calculation)
$(x_{c_6})_1 = 0.125$ (0.11 from algebraic calculation)

For the plate just above the first plate from the still,

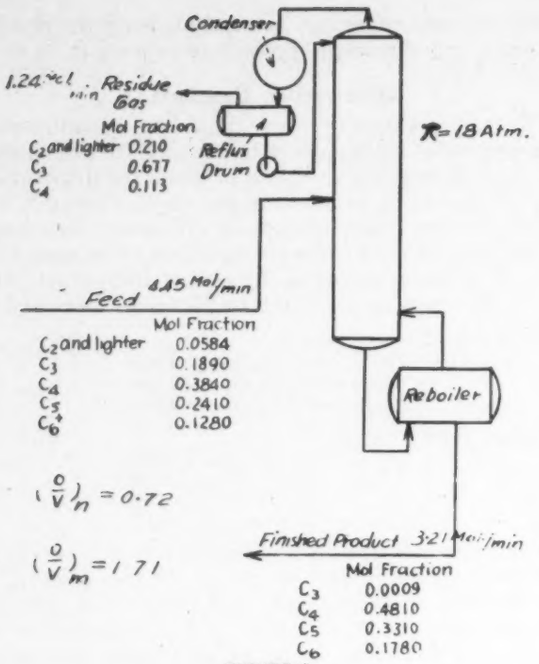


FIGURE 2

the procedure is repeated. As a first approximation, $T_1 = 268°$ F. thus

$$(Kx_{c_3})_1 = 0.0041$$
$$(Kx_{c_4})_1 = 0.840$$
$$(Kx_{c_5})_1 = 0.227$$
$$(Kx_{c_6})_1 = 0.053$$
$$\Sigma(Kx)_1 = 1.1241$$
$$\therefore \quad (y_{c_3})_1 = (Kx_{c_3})_1/\Sigma(Kx)_1 = 0.00364$$
$$(y_{c_4})_1 = 0.747$$
$$(y_{c_5})_1 = 0.202$$
$$(y_{c_6})_1 = 0.0471$$

The correct temperature is traced back from $(y_{c_5})_1$. Thus, $T_1 = 252°$ F. (test data 254° F.).

From operating lines

$$(x_{c_3})_2 = 0.0026 \text{ (0.0027 from algebraic calculation)}$$
$$(x_{c_4})_2 = 0.64 \text{ (0.66 from algebraic calculation)}$$
$$(x_{c_5})_2 = 0.257 \text{ (0.245 from algebraic calculation)}$$
$$(x_{c_6})_2 = 0.107 \text{ (0.09 from algebraic calculation)}$$

Calculations for plates along the column from the bottom up are entirely similar. The results check well with Gunness' algebraic calculation. Actually, the results have to be the same as the principles involved are entirely the same except that the values of K's and the operating equations employed are slightly different.

Calculating from top down, the manipulation is analogous. Thus, starting from the condenser we have

$$(y_{c_3})_c = 0.21$$
$$(y_{c_4})_c = 0.677$$
$$(y_{c_5})_c = 0.113$$

As a first assumption, the condenser temperature is taken as 120° F. A vertical line $T = 120$ is drawn on the right side of Figure 1 which cut the "equal K lines" for c_3, c_4 and c_5 at a′, b′, and c′, respectively. Horizontal lines are drawn through these points to cut the K line at ka′, Kb′, and Kc′ respectively. Values of $(y)_c$'s are read off on vertical axis and horizontal lines are drawn from these points. These horizontal lines intersect with the vertical lines drawn from Ka′, Kb′ and Kc′ at Ia′, Ib′ and Ic′ respectively. Lines drawn from Ia′, Ib′ and Ic′ parallel to $x = y$ give readings of ya′/K, yb′/K and yc′/K respectively on the vertical axis. Thus

$$(y_{c_3/K})_c = 0.076$$
$$(y_{c_4/K})_c = 0.64$$
$$(y_{c_5/K})_c = 0.25$$
$$\Sigma(y/K)_c = 0.966$$
$$\therefore \quad (x_{c_3})_c = 0.0787 \text{ (test data 0.072, algebraic calculation 0.1)}$$
$$(x_{c_4})_c = 0.663 \text{ (test data 0.70, algebraic calculation 0.59)}$$
$$(x_{c_5})_c = 0.259 \text{ (test data 0.22, algebraic calculation 0.31)}$$

Tracing back from $(x_{c_4})_c = 0.259$, it is found that $T_c = 118°$ F. (algebraic calculation, 118° F.).

From the operating lines

$$(y_{c_2})_t = 0.12$$
$$(y_{c_3})_t = 0.66$$
$$(y_{c_4})_t = 0.22$$

For the top plate temperature, 118° F. is taken as the first approximation. Thus it is found

$$(y_{c_2/K})_t = 0.045$$
$$(y_{c_3/K})_t = 0.645$$
$$(y_{c_4/K})_t = 0.500$$
$$\Sigma(y/K)_t = 1.190$$
$$\therefore \quad (x_{c_2})_t = 0.0378 \text{ (0.06 from algebraic calculation)}$$
$$(x_{c_3})_t = 0.542 \text{ (0.54 from algebraic calculation)}$$
$$(x_{c_4})_t = 0.420 \text{ (0.42 from algebraic calculation)}$$

Tracing back from $(x_{c_4})_t = 0.420$, it is found that $T_t = 138°$ F. (140° F. from algebraic calculation).

The vapor compositions are read off from the operating lines, thus

$$(y_{c_2})_{t-1} = 0.077$$
$$(y_{c_3})_{t-1} = 0.592$$
$$(y_{c_4})_{t-1} = 0.331$$

For the next plate down, T_t is used for T_{t-1} as an first approximation, thus

$$(y_{c_2/K})_{t-1} = 0.026$$
$$(y_{c_3/K})_{t-1} = 0.467$$
$$(y_{c_4/K})_{t-1} = 0.630$$
$$\Sigma(y/K)_{t-1} = 1.123$$
$$\therefore \quad (x_{c_2})_{t-1} = 0.023 \text{ (0.025 from algebraic calculation)}$$
$$(x_{c_3})_{t-1} = 0.416 \text{ (0.43 from algebraic calculation)}$$
$$(x_{c_4})_{t-1} = 0.560 \text{ (0.55 from algebraic calculation)}$$

Tracing back from $(x_{c_4})_{t-1} = 0.56$, it is found that $T_{t-1} = 150°$ F. (162° F. from algebraic calculation, 154° F. by interpolation of test data.)

With the methods of operation thus illustrated, it can be seen that a complete solution of a multicomponent fractionation problem can be obtained in a relatively short time.

Nomenclature

x = mole fraction in liquid
y = mole fraction in vapor
K = equilibrium constant
T = temperature
π = total pressure

Subscriptions:

n = section above feed
m = section below feed
c = condenser
t = top plate
t − 1 = next plate from top plate down
w = still
1 = first plate from bottom up, excluding still
c_2, c_3, c_4, etc. = components; that is, c_2 signifies ethanes fraction.

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Increasing Production With Clean Condensers

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REFINERY operations involve so much heat-transfer equipment that scale and corrosion problems are a recurring headache in most plants. This is true of our own plant with a 6500-barrel design capacity recently increased to approximately 8500. Our production is confined to gasoline, kerosine and fuel oil, utilizing two crude units and one Dubbs unit. Scale formation in our cooling system has been a difficult problem only recently brought under control. The atmospheric cooling system introduces a number of water problems which may be briefly outlined.

Problems occurring in these systems are influenced by atmospheric contamination from gases, such as oxygen, carbon dioxide and hydrogen sulfide, bacteria, algae, and dust which frequently introduces appreciable amounts of silica into the equipment. Velocity, temperature and incomplete wetting of metal surfaces are design features and a variety of metals and alloys present in systems encourage and introduce water problems inherent to the systems, unless corrective treatments are employed.

Corrosion occurs commonly in atmospheric cooling systems because of the repeated aeration of the water. The problem is not solved conveniently by oxygen removal because of this fact. The high velocities present in condensers accelerate the corrosion rate. The rate of corrosion is increased still further by the multiplicity of voltaic couples normally present in large cooling systems.

Living organisms are a serious problem in cooling systems and algae, bacteria, or both may be factors responsible for scale, corrosion, or simply slime found on heat-transfer surfaces. Aside from repeated contamination due to atmospheric contact, the property of many of these organisms of developing resistance to unfavorable environments, including chemicals intended to destroy them, is a difficult and disconcerting factor in their control.

Our water conditions are reflected in the analysis in Table 1. The cooling water conditions are frequently more severe due to evaporation and atmospheric contamination but the water is quite hard under normal conditions and scale formation on our condenser tubing has accordingly been severe. This reduction of heat transfer rates not only reduces profits but seriously reduces production at a time when production is necessary for war efforts.

At our plant we have a cooling tower (Figure 1) which was erected in the original cooling-water pond and which is of ample capacity to handle the required volume of cooling water. The water recirculates at the rate of 800 gallons per minute, and after leaving the condensers and coolers, empties into a

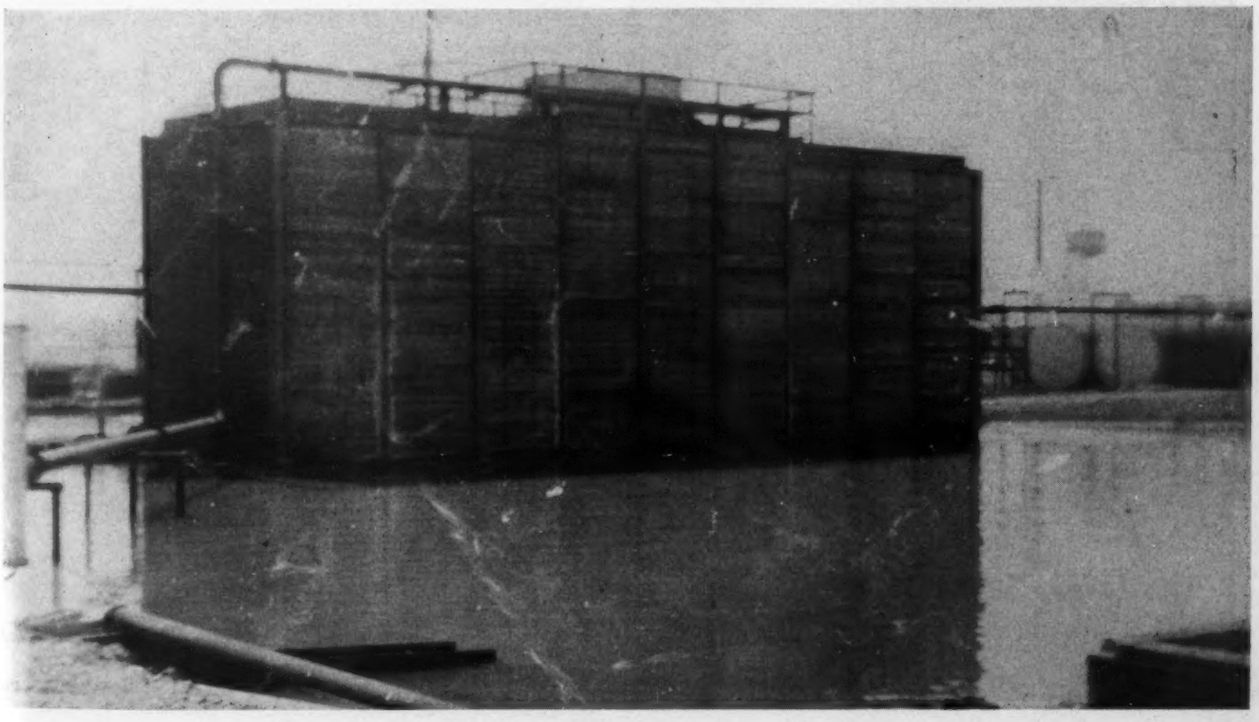

FIGURE 1

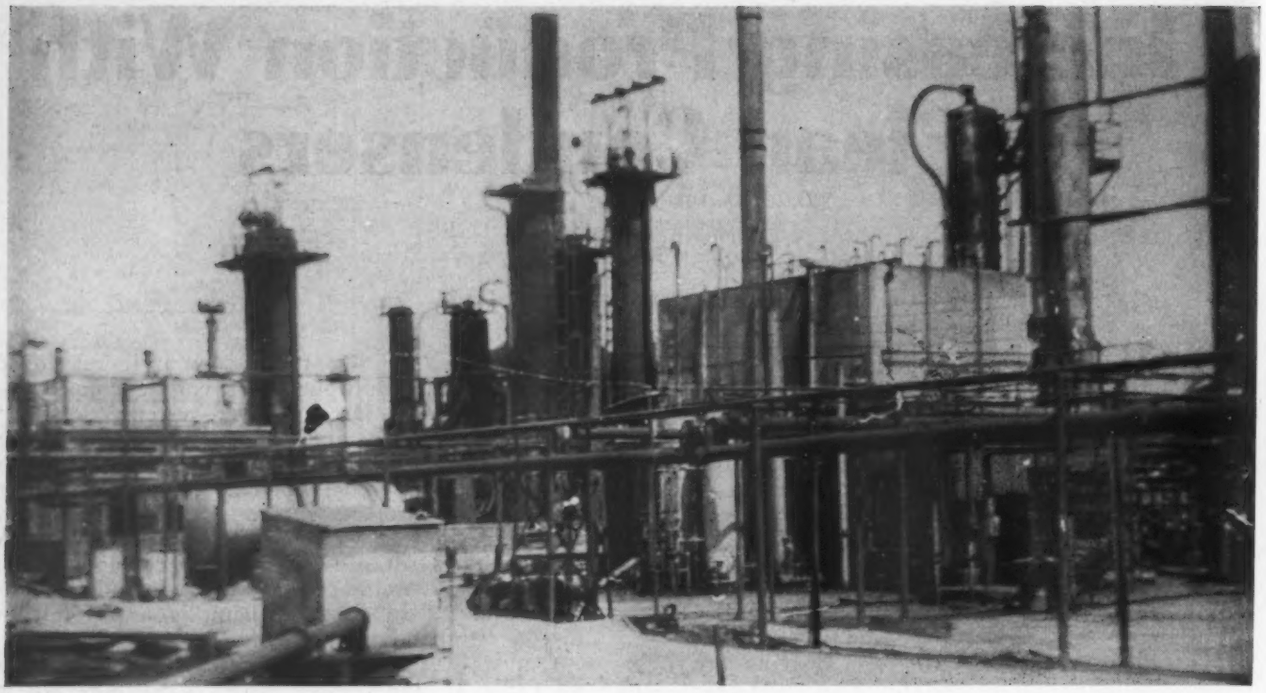

FIGURE 2

hot well. From here it is picked up and goes over the cooling tower into the basin below. Figure 2 is a partial picture of the stills.

An ample water supply and adequate cooling facilities, however, are not sufficient for efficient production unless the condenser surfaces are kept clean. The scale accumulation on our condenser tubing ranged from one eighth- to one half-inch in thickness, and interfered seriously with heat transfer. We were using a chemical treatment, supplied by a nationally known concern, which apparently failed to accomplish its purpose and to control this accumulation.

Faced with a serious condition we decided to make a change in our chemical water treatment, and adopted a mixture of cupric chrom glucosate and tetra phospho glucosate recommended by a firm of water consultants. The cupric chrom glucosate was used for the control of algae and corrosion and the tetra phospho glucosate to control scale and inhibit corrosion.

The results of this chemical control were immediately apparent. Within 90 days heavy scale began dropping off the lower side of the tubing, and could be pushed off the upper side. In some of the boxes the tubing is set so close that the scale did not have room to drop and simply laid loose on the tubing. Figure 3 shows scale with cracks in it, demonstrating the manner in which it was loosened from

FIGURE 3

TABLE 1

IONS	P.P.M.	
	Raw Water	Cooling Water
Bicarbonate	271.0	315.0
Carbon dioxide	7.0	None
Oxygen	3.2	2.0
Chloride	14.0	14.0
Sulfate	64.0	67.0
Silica	22.0	25.0
Phosphate	None	Trace
Calcium	90.0	93.0
Magnesium	5.9	6.3
Iron	1.7	5.9
Hardness as $CaCO_3$ (Calc)	249.0	251.0
Hardness (soap)	220.0	240.0
Alkalinity	271.0	315.0
Acidity	8.0	None
Dissolved solids	598.0	686.0
Suspended solids	6.0	15.0
Total solids	604.0	701.0
Volatile and organic matter	188.0	201.0
Oil	Considerable	Considerable

the tubes. Even though it could not drop off, the fact that it was loose premitted the cooling water to get under it and reach the tubing. When a still is down for any reason we get into the boxes and remove the loose scale. Figure 4 shows a pile thrown out at one end of a box. Another and much larger pile was thrown out at the other end of this same box.

In one of our boxes the tubing is not submerged, but is cooled by sprayed water. These boxes had always been a source of considerable trouble but now we find that at those points where the water falls in any volume the scale has been removed sufficiently to show the bare metal. Figure 5 is a view of one of the boxes of spray-cooled tubing. The upper pipes, going cross-wise in this illustration, show some scale, but they are the pipes which spray the cooling water onto the tubing beneath, and the small amount of treated water which falls on the outside of these upper supply pipes is not sufficient to completely remove all scale. Some of the tubing in this photograph appears slightly scaled, but most of the roughness showing is at those points where the water volume is not great enough to carry an adequate amount of treatment for complete scale removal. The clean edge of the nipples at the pipe joints shows there is practically no scale accumulation.

The proof of the pudding, however, is in the eating, and the proof of the value of any chemical treatment is in the results obtained. Our result has been an increased gasoline output of 50 barrels daily, which pays for the cost of the treatment and leaves a substantial profit. Anything which lowers cost and increases production is welcome in any plant at any time, but today we have a bigger and better reason for everything we do. Today America is at war. Today we must increase production, stamp out inefficient methods forming production bottlenecks, conserve all metals and increase the life of all metal equipment. Through the treatment of water we can increase the production of gasoline and other equally essential defense materials.

FIGURE 4

FIGURE 5

Metallizing to Prolong Life of Equipment

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UNDER present conditions it is difficult to get repair parts for refinery and gasoline plant operations. Even with high priority ratings, long and costly delays are sometimes encountered before repair parts can be obtained. In order to save time and metal, many plant managers are turning to the metallizing process. Some refiners have used this process over a period of years and need no urging to expand the scope of this department. Others may have tried the process once or twice without getting satisfactory results, due mainly to the use of the wrong metal or in faulty operation of the equipment. The process is not a cure all but it does have several distinct and unique advantages. If one or two points are always remembered when making use of this process, there will be little difficulty in obtaining good results. First, the deposited metal is not welded to the base metal. The bond is purely mechanical and for this reason the preparation must be thoroughly and carefully done. Second, regardless of the kind of wire used the metal is "cast" and therefore should be machined and handled like a casting. This cast metal provides an excellent wearing surface, usually wearing several times longer than rolled metal of the same specification.

The most frequently made refinery applications are: resurfacing pump rods and shafts, building up bearing and packing areas on steam turbines, pistons and piston rods on gas engines and air compressors, seal rings in centrifugal pumps, filling in cavitated areas of centrifugal water pumps, and many others that will occur in normal shop operation.

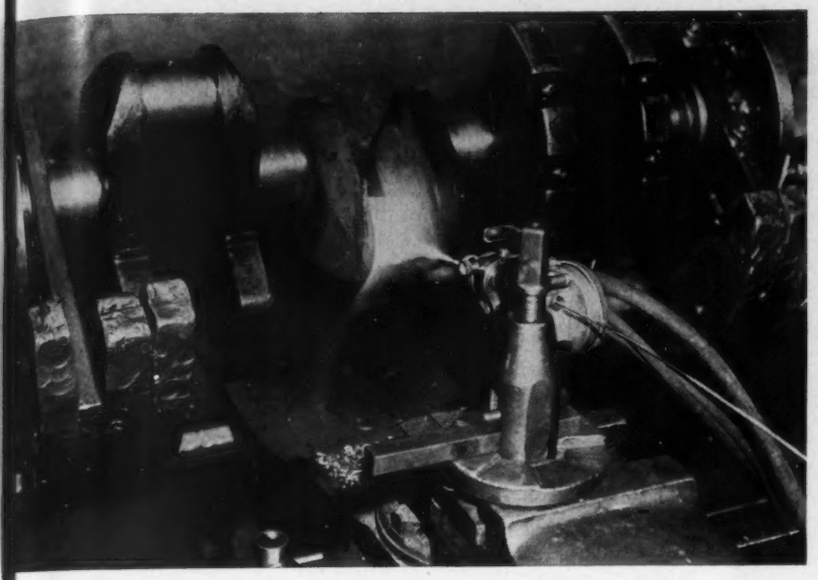
Compressor rod being salvaged by spraying

In the past, there has not been very much attention paid to the selection of the best man to operate the metallizing department. In most plants there is at least one man who is handy with tools and equipment and if let alone can "repair anything." A man of this type will make a good metallizer if given some encouragement. After selecting a good man, see that he is provided with the best equipment, a good place to work, and time to experiment and practice. In the course of a day or so he will be turning out quality work.

Metallizing is divided into two classes: machine element or items that are prepared in a lathe, and flat surfaces that are prepared by sandblasting. Both of these classes are important to the refiner but due to some restrictions in the use of certain metals like aluminum, the machine element class will rank first for the duration. Some flat surface jobs can be done where either zinc or lead is the metal to be applied.

The most common of all machine element jobs is the building up of worn pump rods or plungers. Let us take such a job and follow through all the steps necessary to restore it to service. First the proper metal must be chosen for the service involved. If the service requires both wear and corrosion resistance, then 13-16 percent chrome steel wire will be the best. If wear alone is the important consideration either a 1.20 percent carbon steel or a 1.00 percent carbon and 2.00 percent chrome steel wire will be satisfactory. Where corrosion alone is the factor, either stainless steel, one of the bronzes, or a high-carbon iron will be used, depending upon the chemical condition encountered. Having determined the best wire to use, the rod is next placed in the lathe and a trueup cut taken over the entire length of the worn section overlapping at each end about ¼-inch, so there will be no joint coming under the packing. The depth of the cut should be deep enough to allow for future wear without exposing the base metal. On pump rods over one inch in diameter, it is customary to undercut 3/32-inch on the diameter. For smaller rods this is reduced to 1/16-inch. See that the rod is cleaned with emery cloth for a distance of about one inch beyond the undercut section. Square the shoulder at each end using a cutter off tool. The bottom at this point should have a small radius to prevent starting a crack.

The rod is now ready to be rough threaded. Use an ordinary threading tool that has had the side clearance ground away and the point slightly rounded. Set the point of the tool about 1/16-inch below the center of the rod and with spindle speed reduced by the back gear run a thread the entire



Building up large crank shaft. This is one of the popular applications today for metallizing as new crank shaft forgings are impossible to obtain.

length of the undercut area (24 threads per inch). The object of this operation is to obtain a thread with a smooth bottom and well torn sides, giving literally thousands of interstices for the sprayed metal particles to splash and lock around. Different alloys will require slightly different tool settings and speeds to obtain the best results. A little practice with the different steels usually used in the plant will soon familiarize the machinist with the correct setting. After completion of the threading operation due care must be exercised that the surface does not become contaminated in any way. Onlookers have a bad habit of trying to "feel" the roughness with their bare hands, leaving perspiration and grease on the threads. If the spraying cannot be done at once, the area should be wrapped in clean paper. It is best to spray the rod as soon as the threading is complete since delay may allow moisture from the atmosphere to deposit and cause trouble. The maximum time permissible between preparation and spraying depends upon the weather. When the humidity is low as much as 24 hours may elapse without any danger of contamination occurring. On wet days spraying must be done within a short time after the rod is prepared.

For convenience, the metallizing gun is mounted in the lathe tool post. The various adjustments in the gas pressures are made and the gun moved opposite one end of the prepared rod. The gun is lighted and the final gas and air cap adjustments made with the gun pointing away from the work so that no metal will be deposited until proper atomization is attained. Point the gun at the center of the shaft and spray until the rod is built up enough over size to allow for finishing. When one spot is built up move the carriage along enough to start a new one. Continue in this manner until the rod is built up for its entire length. Unless for some reason it has been necessary to undercut the rod very deep, it is best to build up with one pass of the gun. Where exceptionally deep deposits must be made, then two passes will be more satisfactory if care is taken to see that the first pass fills about half of the total depth. The finishing, if done in the lathe, can be started as soon as the spraying is completed. By the time the rough cut is completed the rod will be cold enough to finish to size. Where grinding facilities are available, it is best to grind the finish regardless of the type of steel used.

Some alloy shafts are either case hardened, nitrided, or so hard all the way through that ordinary machine tools cannot be used to undercut the worn area. In this case, grind the necessary metal away, mask the ends and sand blast thoroughly. If possible use a diamond point chisel to nick the area before sandblasting. Replace in lathe and spray as indicated above.

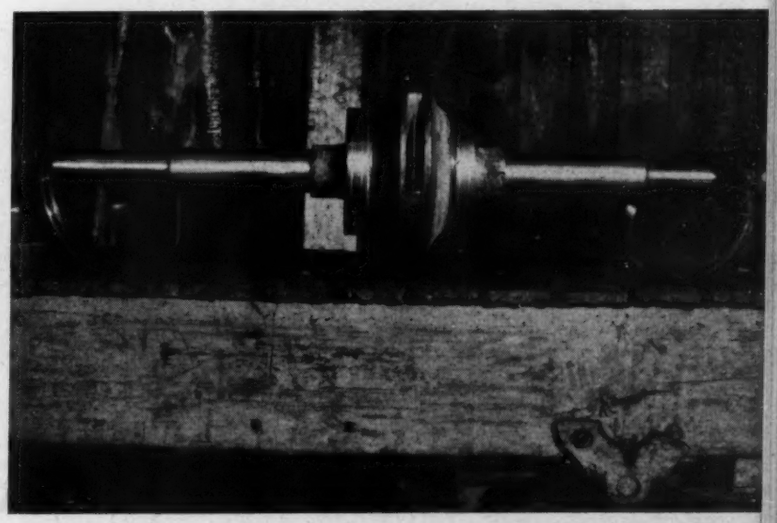
In preparing used cast iron, bronze or brass casting for metallizing they must be heated hot enough to drive off any oil or grease that may have been absorbed. The heating should be done with care so there will be no warping. Previously welded shafts also may have absorbed some oil.

Since the base metal rarely gets hotter than about 200° F. above the atmosphere when being metallized, it is obvious that crankshafts, high-speed shafts, armatures, turbine shafts and many other items may be built up with this process without the danger of warpage from heat.

Application to Vessels

The next most important application of metallizing in the refinery is the protection of steel vessels and structures from all kinds of corrosion. The surfaces of these items are prepared for metallizing by sandblasting. Where possible, steel grit should be used in blasting. In warm coastal areas it is impractical to use this material because the salt air causes the steel shot to rust overnight. The small particles of rust on the shot are then transferred to the surface to be sprayed. The rust particles are so small that detection is difficult. If metal is deposited over the rust particles, failure will be the inevitable result. In all localities where steel grit cannot be used, a flint grit should be used. The grit used should be very sharp since the object is not only to clean the surface but to produce a tearing action necessary to obtain a keyed surface to grasp the little particles of sprayed metal and hold them tightly. Since the success of

Showing how parts can be built up without disassembling



Spraying of new material on a cylindrical surface could be done in the machine lathe where the surface is roughened preparatory to the rebuilding, but where much work is to be done, a simple rotating device and hand-operated gun rest, provide ample work and inspection facilities and release lathe for other work. Rotation is at speed to permit build up of desired thickness in single pass of gun over work.

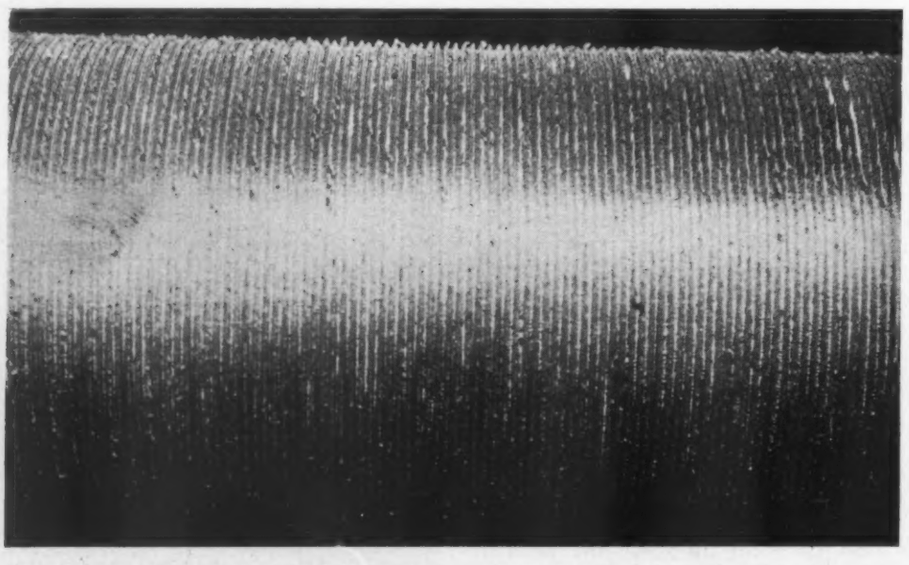
the metallizing operation is so closely tied in with the sandblasting, it follows that a great deal of care must be taken to get satisfactory results every time. Be sure that the size of the blasting nozzle is not too large for the supply of compressed air available. If the blasting is started with a nozzle ¼-inch in diameter and it wears until it is 5/16-inch, then the volume of air required to keep the pressure constant is increased from about 95 to 145 cfm at 90 pounds. If the increased volume is not available then the pressure at the sandblasting machine drops so low that good work cannot be expected. A good air filter should be installed at the machine to remove all entrained oil and moisture from the air. Clean only an area that can be completely metallized in the course of the shift. Until the operators become proficient in estimating the amount of wire used per square foot, it is best to measure the surface and weigh out the wire necessary to cover this area to the correct depth.

In spraying flat surfaces, it must be remembered that the thickness of the applied metal is very definitely limited. From some inspections made recently, it appears that many operators think that if a little is good, a lot will be that much better. Nothing could be more fallacious, since if too much metal is deposited its strength becomes such that the mechanical bond is sheared when the base metal expands or contracts. A thinner coat is not so rigid and the bond is sufficiently strong to stretch the small amount necessary for it to follow the base metal. Each metal has a different thickness limitation.

After completion of the job, remember that the coating is comparatively thin and sharp edged or pointed tools should not be used for subsequent cleaning operations. In applying zinc, the metal as sprayed needs no further preparation if the structure is to be painted.

Metallizing equipment on the market today will operate on propane, butane, natural gas, waste refinery gases, acetylene or hydrogen. In common practice, most refineries use propane as the fuel. The use of refinery gases where available will produce satisfactory results if the sulphur content is low enough so none will be taken up by the metal while in the molten state.

Before disposing of your scrap pile, take another look to see if some pieces of equipment discarded in former years can not be salvaged by the process described above.



To form anchorage for the metal as it is sprayed onto the part being built up, preliminary processing includes the formation of a rough surface. In the case of cylindrical parts, such as the pump rod shown, a thread is turned on the worn surface, with the lathe tool set slightly off center to produce a tearing effect rather than smooth turning. Into the recesses, cavities and corrugations thus formed the molten metal is forced and in cooling, is locked firmly to the underlying material, addition being checked by eye and caliper as work progresses.

Simple, Efficient Platform for Pipe Bending

BENDING piping of various weights and sizes to special shapes is not difficult when proper equipment is provided for this work. When one or more pipe bends are to be made that cannot be accomplished with cold pipe or where operating conditions require smooth interior surfaces, one company has found it advantageous to use a simply designed bending platform that provides a wide variety of shapes.

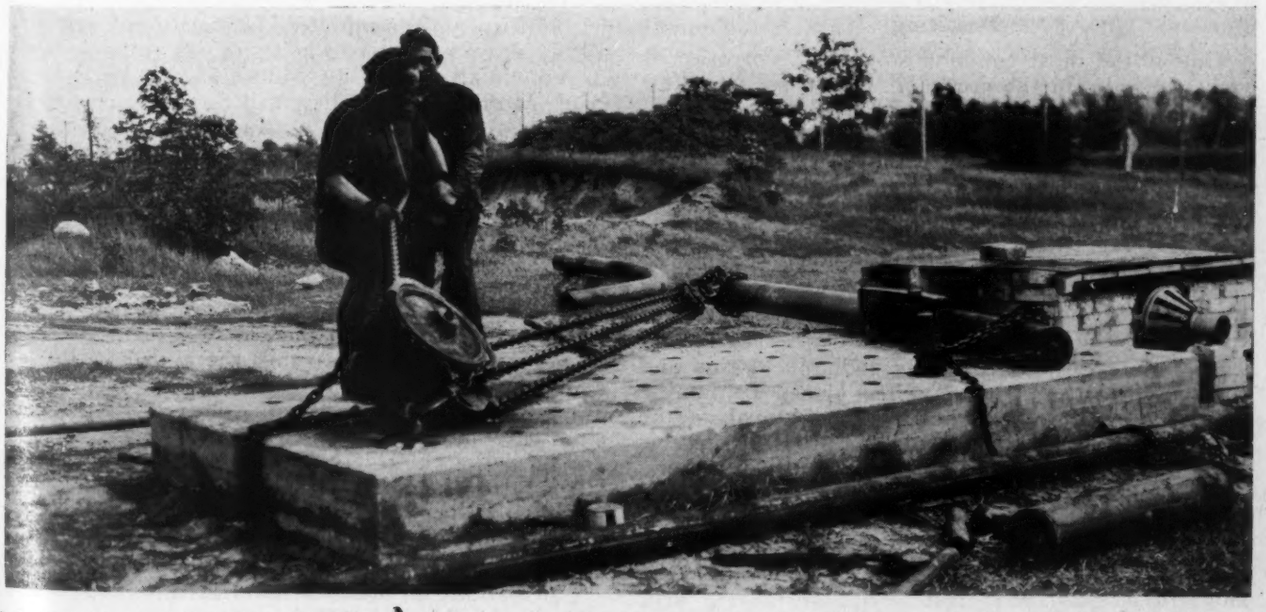
Briefly the device consists of a concrete slab into which have been sunk a number of pipe nipples, a heating furnace, a heavy-duty chain hoist, and a shaper. After heating, the proper shape is obtained by inserting iron pegs in a selected series of the nipples. Chaining one end of the pipe joint to two of the iron pegs, placing the correctly styled shaper against two nipple-inserted iron pegs opposite the heated part of the pipe, and pulling on the other end of the pipe with the chain hoist accomplishes the job.

The first move in building a bending platform of this type is the excavation of a vertical-walled, smooth-bottomed pit, 13 feet long, six feet wide and two feet deep. This is filled with concrete extending to a height one foot above ground level. Before pouring the cement mix, which requires about 8½ yards, 55 two-inch plain end nipples about 24 inches long are hung vertically in the concrete form on 12-inch centers (see illustration). This number of nipples makes five rows of 11 each, the outside nipples being set approximately one foot in from the outside of the edge of the concrete form. The nipples are hung so their upper lip will be flush with the concrete flooring when poured. In one corner, near the nipple at that location, an extra heavy ring, or U-bolt, set well down in the concrete, is placed. This U-bolt is employed as an anchor for a heavy chain hoist used in procuring sufficient pressure to bend the pipe.

At one end of the platform, a gas fired furnace is built. The firebox, or heating section, is made of firebrick, with an open top. The top of the heat consists of sheets of removable light weight iron. Both ends of the heater are partially open so a joint of pipe can be slipped through from the bending platform.

Accessories required for active work when making bends consist of several pieces of tough bar iron, several short lengths of chain and a shaper. The bar iron or retaining pins are of a diameter that will permit them to easily slip into the sunken pipe nipples of the concrete platform. These pegs are of sufficient length so they will extend approximately one foot above the concrete platform surface when inserted in the sunken nipples. The short lengths of chain are for anchoring the joint of pipe at one end and for providing means of attaching the hoist hook at the other end. The shaper is a short piece of channel iron, which has been shaped or forged to the desired angle the pipe is to be bent.

Two men working patiently with the pipe can procure any degree of arc desired when given this shaping platform.



A heated piece of pipe being bent on the bending platform. If it commences bending too rapidly, water is poured over the part bending too rapidly until it is cooled and therefore stiffer. Note series of nipple holes in concrete platform, making it possible to obtain different arc degrees.

Laboratory Control Reduces Refinery Corrosion

A. W. TRUSTY

THE war, with priorities and metal shortages, has put certain refining equipment and metals into the "precious metal" class. The refinery personnel must now devote more time and effort to protection of the existing equipment. Many corrosive conditions in the past were breakeven cases as to whether to spend the money to combat corrosion by chemical or other means, or to take the corrosion and replace the metal. However, today in many cases, it is a matter of saving the metal in spite of a high protection cost.

The chemist and metal inspector or corrosion engineer by close cooperation can first assemble the facts and conditions surrounding a corrosion case and then can intelligently apply the proper corrective measures. For example, an analysis of the iron content of the condensed water from the distillate streams and a knowledge of the quantity of water per day will enable the extent of corrosion to be determined. An analysis of the iron content of the water before and after the addition of alkali to the distillate stream will enable the engineer to determine the degree of protection that he is obtaining.

Desalting

One of the most common sources of corrosion is from the salts in the crude oil. There are very few refineries now which have not installed desalting equipment of some kind. The maximum amount of salt permitted in the treated oil varies with the refiner and with the nature of the salts. A salt content of 20 pounds per 1000 barrels of oil is considered a satisfactory figure by most operators; however, where the salt content can be completely removed fairly easy, some refiners feel that they are justified in the slight increase in expense necessary to practically free the oil of salt.

Some brines contain mostly sodium chloride and give less corrosion than other brines containing magnesium salts. The chemist should analyze the briny water from each crude oil processed at his plant to determine the relative proportions of sodium, calcium and magnesium ions. Where calcium and magnesium are present, the total salt content of the crude oil should be reduced to a lower figure than in the case of a brine containing only sodium chloride.

Salt is most commonly encountered in crude oil in the form of brine drops. It is only the very small brine droplets which are difficult to remove from the oil. Larger drops, exceeding 0.01 mm in diameter, settle readily and are removed from the crude oil in the field.

The presence of wax contributes to the difficulty of salt removal. Both brine drops and solid salt crystals are stabilized by a thin coating of wax. It is necessary to heat the oil to a temperature above the solution temperature of the wax in the crude. A temperature of 120° F. will dissolve the wax in East Texas crude while a temperature of 160° F. is required to dissolve the wax in Rodessa crude oil.

The salt content of an oil is usually determined by diluting the oil with an organic solvent to decrease the viscosity and to minimize emulsion formation, followed by thoroughly agitating the oil with warm water, settling, and analyzing the water extract. The water extraction is quite satisfactory in cases where the salt occurs in the form of brine solutions. If the salt is present in the form of crystals, however, it has been found that prolonged shaking does not completely dissolve the solid salt.

Centrifuging, likewise, will remove crystalline salt with difficulty. Ten minutes of centrifuging removed all of the water, but two hours of centrifuging failed to remove all of the salt from a sample of Rodessa crude containing crystalline salt.

A quick method for the determination of the salt content of a crude oil is as follows: Place 100 ml of the crude oil in a 500 ml separatory funnel and add 100 ml benzene. Add 25 ml acetone and swirl for a few seconds to break up any brine emulsion. Add 100 ml of very hot distilled water. Shake thoroughly for 5 minutes. Immediately while air bubbles are trapped in the mixture add an additional 25 ml of acetone. Do not agitate the solution further at this point; invert it gently to mix the acetone with the solution. Allow to settle. Withdraw the water layer and titrate with silver nitrate solution using potassium chromate indicator. Repeat the extraction process until the chloride equivalent is less than .5 ml silver nitrate per extraction. Thorough shaking and removal of the water in each extraction aids in keeping the number of extractions down. Use a blank titration deduction for each titration.

Calculation: ml .0488 N silver nitrate $\times$ 10 = lbs. sodium chloride per 1000 barrels of oil.

An analysis of the salt water extracted from the

crude oil will show the relative content of sodium, calcium, and magnesium chlorides. Sodium chloride gives no acidic decomposition product. The presence of calcium chloride in a brine containing magnesium chloride causes the acidic decomposition products formed by the magnesium salt to be inconsistent in yields—in some cases, the acidity is actually depressed. The hydrochloric acid release from the distillation of a crude oil containing magnesium chlorides will vary with several factors, such as the temperature of distillation, the quantity of steam used in the process and the time element during the distillation. A magnesium chloride content of 20 pounds per 1000 barrels of oil would produce about 8 pounds of hydrochloric acid in a typical topping operation.

The quantity of acid produced by distillation[1] can be estimated in the laboratory as follows: Charge 500 ml of the crude oil into a 1000 ml side-neck flask fitted with a steam connection. Connect the flask to a condenser and the condenser to an Erlenmeyer flask. Connect the vent from the flask to an ASTM sulphur determination absorber (D 90-34T). The absorber is charged with 45 ml of 1/16 N sodium carbonate solution (3.306 grams per liter).

The oil is heated and steam is applied at an oil temperature of 240° F. The distillation is continued at a rate so as to reach an oil temperature of 650° F. in 1 hour. Sufficient steam is used to give about 40 ml of water condensate overhead. The overhead is water-washed twice in a separatory funnel and the wash water added to the absorber. The solution in the absorber is back-titrated with standard hydrochloric acid (.08623 N) using methyl orange as an indicator. (ml acid for blank — ml acid for titration) $\times 2.2$ = lbs. hydrochloric acid per 1000 barrels of oil. This laboratory method makes it possible to compare the acid products which might be obtained from the various crudes processed at a plant before and after the desalting operation.

Procedure for Determination of Calcium, Magnesium and Sodium[4]

Agitate thoroughly in a 2-liter separatory funnel 100 ml of the crude oil and 500 ml of benzene. Add 100 ml of acetone to break up any emulsion. Extract with 400 ml portions of hot water until the extract gives no test for chlorides. Combine the filtered extracts and evaporate to 125 ml. Acidify with 10 ml of 6N hydrochloric acid and filter again to clarify. Oxidize any iron with 5 ml of bromine water and boil off the excess of bromine. Make slightly alkaline with ammonia and filter off the iron and aluminum hydroxides.

Concentrate the filtrate to 75 ml, add ammonia if the odor is not detectable, and to the boiling solution add ammonium oxalate, drop by drop until no more precipitate appears. Finally add an excess of 10 ml of ammonium oxalate. Boil with stirring and digest until the precipitate settles out. Filter at room temperature. Wash twice with warm water containing ammonia and a little ammonium oxalate solution, heat to boiling, and add a slight excess of ammonia. Cool and filter as before. Add the washings to the filtrate from the first filtration. Ignite the precipitate and weigh as calcium oxide.

Evaporate the combined filtrates and washings until crystals begin to appear. Add 1-2 ml of dilute HCl, and with stirring add water 1 ml at a time until the salts redissolve. If the acid solution is not clear at this point it must be filtered. Make barely alkaline to methyl orange with ammonia. To the cold solution add sodium ammonium phosphate solution as long as precipitation continues and finally 10 ml in excess. Add 6 N ammonia, 1 volume for each 3 volumes of solution, stir for 10 minutes, and allow to settle for 6 hours.

Filter the precipitate in a weighed Gooch crucible and wash with 2.5 percent ammonia. Ignite to a constant weight and weigh as $Mg_2P_2O_7$.

Calculation: grams CaO/1000 ml oil $\times$ 693.7 = lb. $CaCl_2$ per 1000 bbl. oil.

grams $Mg_2P_2O_7$/1000 ml oil $\times$ 299.8 = lb. $MgCl_2$ per 1000 bbl. oil.

Calculate the remainder of the chlorine to sodium chloride.

Topping Plant Corrosion

Practically all corrosion on the oil side at the topping plant is caused by hydrochloric acid and/or hydrogen sulfide.

The hydrochloric acid is formed by decomposition of the chlorides of magnesium and calcium during the process of heating. A small amount of hydrochloric acid will greatly accelerate the rate of corrosion from hydrogen sulfide. A vicious cycle is set up as follows: the hydrochloric acid attacks the iron to form ferrous chloride. The iron of the ferrous chloride is then precipitated as iron sulfide by the hydrogen sulfide, thus freeing the hydrochloric acid for another attack on the iron.

The hydrogen sulfide may have two sources: naturally occurring in the crude oil, or formed by decomposition of the other sulfur compounds during the process of distillation.

The time and temperature are two factors affecting the quantity of H_2S evolved during heating. For example, a pipe-still unit with a 550° F. outlet temperature produced a doctor-sweet kerosine and no H_2S present in the gasoline streams from East Texas crude oil. A shell-still battery charging the same crude with an oil temperature of 575° F. in the last still produced a doctor-sour gasoline from No. 2 still and a doctor-sour kerosine from No. 3 still.

Corrosion from hydrochloric acid-hydrogen sulfide in the topping plant can be reduced by desalting the crude oil, the use of special metals, such as cast iron, alloys, etc., or the use of alkaline chemicals in the condensing system.

The use of an alkali in an all-iron condensing system will furnish good protection with no danger from an excess of alkali. However, the condensing equipment in most topping-plant units includes both iron and copper alloys, and an excess of alkali will attack the copper alloy. The problem then is one of accurate control of the pH, or reaction value of the streams.

Some refiners report satisfactory service of brass tubes using a pH as high as 8.5 while in other cases attack of the tubes is noticed with a pH of 7.5. This variation in allowable excess of alkali is due to the proportions of hydrogen sulfide and hydrochloric acid present in the stream. The manufacturers of brass tubes usually recommend pH values less than 7.5 for protection of copper alloys. A pH higher than

7.5 is usually recommended for protection of iron.

The condensed water from the streams can be tested for acidity or alkalinity (pH) by the following means:

a. continuous pH recorder[2], or a pH meter,
b. indicator solutions.

Hydrogen Ion Concentration (pH)

The chemist by titration can determine the quantity of acid present in a solution. The quantity of acid present and the intensity vary widely with different acids. For example, we use boric acid as an eye wash and acetic acid in the form of vinegar as a seasoning, but would not dare use hydrochloric acid for such purposes. Actual measurements show that hydrochloric acid has almost 70 times the active acidity of acetic acid, and over 10,000 times the intensity of boric acid. Likewise, sodium hydroxide is almost 100 times as intensely alkaline as ammonium hydroxide although titration by the chemist would show the quantity of alkalinity to be the same.

It is the *intensity* of acidity which is of importance in corrosion. This intensity is more accurately measured by the pH scale. When an acid or an alkali is dissolved in water, they ionize, or break up into positively charged hydrogen ions and negatively charged hydroxyl ions. The intensity of acidity or alkalinity is due to the number of positive or negative ions in a solution. Hydrochloric acid is a strong acid because it gives a large number of positive hydrogen ions. Likewise boric acid is a weak acid because it gives a small number of ions.

The pH value, then, is a measure of the positive or negative ions. A pH value of 7 is neutral, that is, it is neither alkaline nor acid. A pH of 6 is acid and has 10 times as many hydrogen ions as a pH of 7. A pH of 5 is more acid and has 100 times as many hydrogen ions as 7. Likewise 8 pH is alkaline and has 10 times as many hydroxyl ions as a 7 pH. A pH of 9 has 100 times as many negative ions as 7, and so on. The pH scale ordinarily runs from 1.2 to 13.6.

The pH can be measured accurately by an electrical instrument, or the pH can be measured by the use of indicator dyes. The following indicators and their pH ranges are commonly used:

	pH Range	Color Change
Acid cresol red	.2–1.8	red yellow
Meta cresol purple	1.2–2.8	red yellow
Methyl orange	2.9–4.0	red orange
Brom phenol blue	3.0–4.6	yellow blue
Brom cresol green	4.0–5.6	yellow blue
Chlorphenol red	5.2–6.8	yellow red
Brom thymol blue	6.0–7.6	yellow blue
Phenol red	6.8–8.4	yellow red
Cresol red	7.2–8.8	yellow red
Phenolphthalein	8.3–9.6	white red

A .04 percent by weight solution of these indicators is used; in some cases it is necessary to use alcohol as a solvent instead of water.

To make the pH test, add .5 cc of indicator solution to 10 cc of water. For example, the topping-plant operator samples the condensed water from his gasoline streams. Phenolphthalein indicator is added. If the water turns red, the pH is 8.3 or higher. If there is no color change, bromthymol blue indicator is added to another portion of water. If the color is yellow, the pH is below 6. If the color is blue, the pH is between 6 and 7.6 (or higher) depending on the intensity of the color. Thus by the process of elimination and using only two or three indicators in cases where the approximate pH of the water is known, the actual pH of the water can be determined in few minutes by a stillman.

Cracking Plant Corrosion

Corrosion in the high-temperature zone in cracking plants is believed to be due mostly to the action of elementary sulphur. The mechanism of corrosion seems to be the decomposition of organic sulphur compounds, liberating hydrogen sulfide, which in turn is decomposed into hydrogen and elementary sulphur. A grain of the elementary sulphur becomes deposited on the metal, begins to react with the iron to form iron sulfide and thus a pit develops.

Many refiners have found that the addition of lime to the cracking-plant feed results in a marked decrease in the corrosion. The quantity of lime used is .25 to 2 pounds per barrel of fresh feed. One[3] refiner reported an 80 percent reduction in corrosion on a Cross unit cracking Winkler County, Texas, gas oil with a sulphur content of about 1 percent. Lime was added in the proportion of .25 pound per barrel of charge.

Methods of control of the amount of lime added to the cracking-plant stock vary with different refiners. One method is to start out using an arbitrary amount of lime, say .25 pound per barrel and use this same amount until the metal inspectors have had sufficient time to compare the rate of corrosion with runs made before lime was added. If the corrosion has not been reduced considerably, the amount of lime is increased, and further metal inspections made during subsequent runs.

Another refiner uses the pH test on the hot feed as a method of control. To 100 ml of the hot feed is added 100 ml of distilled water and the mixture is agitated. A pH determination is made on the separated water. Sufficient lime is added to the feed to maintain a pH of 8 to 9 on the hot feed.

Addition of lime to the cracking-plant feed always raises the ash and BS&W content of the fuel oil. Thus these two tests can be used as methods of control. One refiner runs the ash content of the fuel oil daily and has set a maximum of .25 percent for control of the lime addition.

Air in Compressor Gases

Most vacuum gas-gathering systems develop leaks, and as a result, air is pulled into the recovery plant. The presence of a small amount of air and water vapor with hydrogen sulfide rapidly accelerates the rate of corrosion. The following table shows the influence of air on H_2S corrosion:

Percent Oxygen in Gas Containing H_2S	Life of Tank Plate in Years
0	20
2	7
4	4½
8	3¾
10	3¾

The oxygen content of the gas can easily be determined by means of the Orsat or Hays apparatus.

REFERENCES

[1] Davis, Ref. & Nat. Gaso. Mfg. P. 271, June, 1938.
[2] Pfarr, Ref. & Nat. Gaso. Mfg. P. 66, Jan. 1942.
[3] Speller, Corrosion, P. 519. McGraw Hill Publishing Co.
[4] Mathews, Ind. Eng. Chem. 13, 325, (1921).

Proper Electrodes For Refinery Welding

WELDON L. ARCHER

WITHOUT a doubt much of the advancement of welding practice may be traced to the progressive engineering in the refining plant. Higher pressures and temperatures suggested the tight joints and heavy shells that would result from welded fabrication. Of course suitable welding electrodes had to be developed to perform these tasks. And the electrodes that resulted solved the question of quality first and then, without delay, turned to the matter of cost. In this field advances have been made also.

Notwithstanding the important part he has played in the development of modern pressure-vessel manufacture, the refiner has not always adopted the same methods for his own welding work. Because of the press of production matters, there has been a natural and understandable delay in the adoption of welding electrodes that would lead to faster welding at lower unit costs without any deterioration of quality. For the same reason the bulk of the welding done about the refinery is accomplished with a grade E6010 electrode. That grade number calls for explanation.

In order to establish standards for welding electrodes the American Welding Society and the American Society for Testing Materials collaborated in the issuance of a specification for welding electrodes. Thus the user of welding is enabled to talk about welding rods in terms of their current characteristics and physical properties by merely stating the grade.

Since this discussion will deal with four of the many grades listed, the first logical step is a table showing the essential factors involved. Table 1 considers the AWS classification number as a guide to welding positions, description of electrode and current requirements, heat treatment and primary physical properties of all weld metal tension specimens.

Although there are four grades listed in Table 1, this article will be restricted to three grades that fall into distinct groups. The discussion will center around the fillet-weld contours that result when a flat position bead is deposited with each type. In this position the resulting fillet welds have a surface that is flat, convex or concave. Therefore the AWS grades may be grouped according to the typical fillet weld surface contour for greater ease of analysis. Following this scheme yields Table 2.

Before going into a detailed treatment of each grade of electrode there are some abbreviations in Table 1 that require explanation. Under welding positions F refers to flat position or downhand position where all the welding is done on a flat surface with the metal being deposited from the top side. Figure 1 shows the flat position. Similarly V indicates the vertical position which is depicted in Figure 2. In the same manner OH designates the overhead position of Figure 3 while H describes the horizontal position of Figure 4.

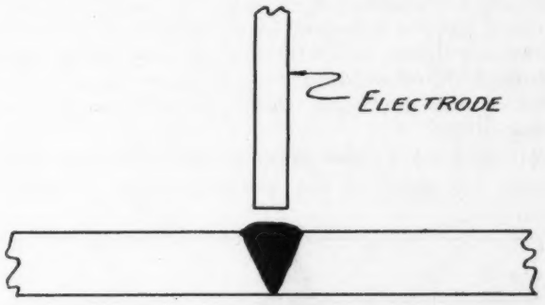


FIGURE 1
Flat or downhead position

Under heat treatment the welds may or may not be stress-relieved. In mnemonic symbols SR indicates a stress-relieving operation of heating to 1100° to 1250° F. and holding for one hour per inch of thickness. Likewise NSR means literally not stress-

TABLE 1
AWS-ASTM Specification for Welding Electrodes

AWS Grade No.	Welding Positions	Description and Current Requirements	Heat Treatment	All Weld Metal Properties	
				Ult. Str. psi	Elong. in 2" Percent
E6010	F, V, OH, H	Heavy covering useful with d-c electrode positive only	SR NSR	60,000 65,000	27 22
E6012	F, V, OH, H	Heavy covering usually used with electrode negative d-c or on a-c	SR NSR	60,000 65,000	22 17
E6020	F, H (Fillets)	Heavy covering usually used with electrode negative or a-c for fillets and electrode positive or a-c for flat welding	SR NSR	60,000 65,000	30 25
E6030	F	Heavy covering usually used with electrode positive on d-c or with a-c	SR NSR	60,000 65,000	30 25

TABLE 2
Electrodes Classified by Fillet Contours

Fillet Contour	Grade
Flat	E6010
Convex	E6012
Concave	E6020 E6030

relieved or when referring to physical properties represents the "as welded" condition.

Choice of Current

Of course d-c means that direct current is used and a-c specifies alternating current. Practically all of the work about a refinery is done with direct current. Where the welding machine is removed from the work as is often the case, a-c with large induction losses becomes impractical. However a-c welding may have a place in shop work and should be considered there. Nevertheless the statement stands that the bulk of welding in the refinery is done with direct current and only this type will be discussed at this time.

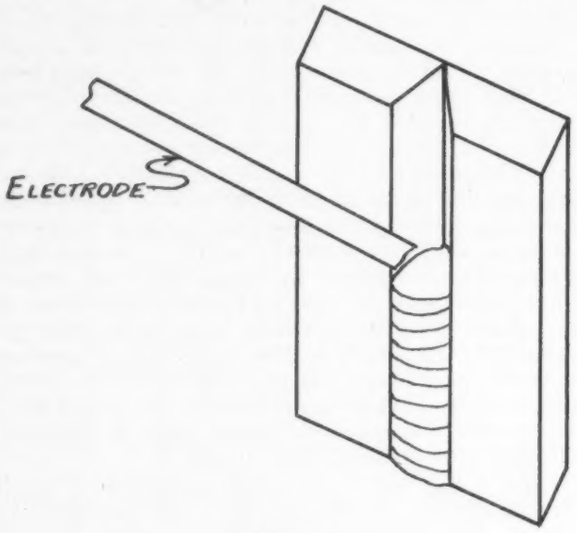


FIGURE 2
Vertical position

Getting back to the grade E6010 electrode which is used for most of the welding about a refinery, what is the reason for its popularity? It may be used in all positions. Definitely that is an advantage as much repair work on existing towers and structures must be done in place. Therefore an electrode that will not perform in the vertical and overhead positions is useless. Then, too, the deposited metal exhibits excellent strength in combination with good ductility. Furthermore many welders in the oil country have a wide acquaintance with this type of welding rod.

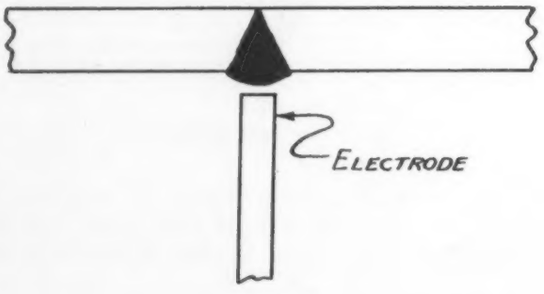


FIGURE 3
Overhead position

With the several good features outlined for grade E6010 electrode there may be some question as to the reasons for having other types of electrode. Surely the flat contour of fillet as illustrated in Figure 5 is good while no fault may be found with the fact that this electrode may be used on direct current, electrode positive (that is, reverse polarity) only. Still there are three definite drawbacks to the universal application of grade E6010 electrodes: slow rate of deposit, likelihood of porosity in the larger sizes and tendency to undercut.

Slow Rate of Deposit

Because of the good all position properties of the E6010 electrodes, many welds are made in the vertical and overhead positions that might as easily be made in the downhand position. The former positions are more difficult for the welder and lessen his actual welding time thereby reducing the amount of metal deposited and slowing down the welding job. Where welding must be done at variance with gravitational forces, E6010 electrodes of small diameters are best. That means welding with 1/8- and 5/32-inch electrodes for the best results. Naturally welds made with small electrodes are slow.

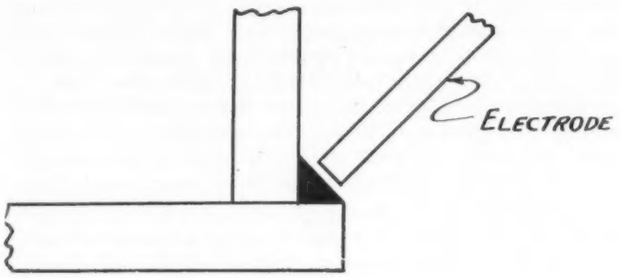


FIGURE 4
Horizontal position

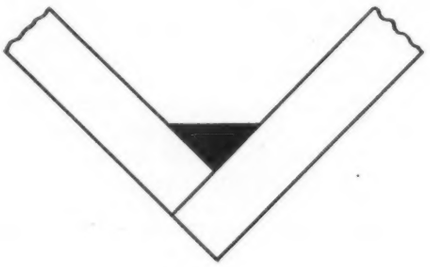


FIGURE 5
Flat fillet weld made with E6010 electrode

Likelihood of Porosity

Grade E6010 weld deposits are inherently porous. This must not be taken to mean that any weld with this class of electrodes will contain gas. But should the welder be lacking in skill or should the welding environment be measurably less than ideal, gas will result. A little gas will be harmless. But excessive porosity must be avoided. To provide a factor of safety against too many gas pockets smaller electrodes, the same diameters as mentioned in the pre-

ceding paragraph, should be used exclusively. By actual experiment the refinery welding personnel can determine the degree of porosity as a function of electrode diameter to prove to their own satisfaction the truth of this statement. Three-sixteenths-inch should be the largest diameter of grade E6010 electrodes carried in stock to avoid porosity troubles.

Tendency to Undercut

Any electrode that is used in reverse polarity has a tendency to undercut in some applications. With grade E6010 electrode this tendency is pronounced. Exacting manipulative skill will eliminate undercut-

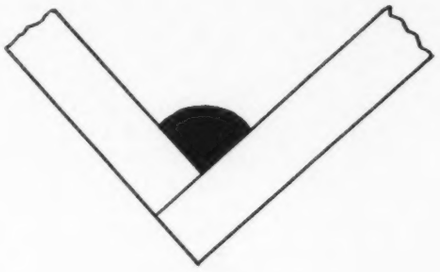


FIGURE 6
Convex fillet made with a E6012 electrode

ting through proper weaving patterns and close arc control. However examination of many welds made with grade E6010 electrodes discloses undercuts that might become stress raisers.

Electrode Applications

High quality deposits with grade E6010 electrodes may be expected to yield sound welds possessing good physicals and excellent resistance to corrosion. These results may be consistently achieved under production welding conditions although costs may be high. If competent welders are employed and the limitations of this type of electrode are recognized, the welds made with it will be good. Where no other electrode can be selected for good cause, E6010 can be used with confidence.

Next is grade E6012. This is a "cold" electrode that makes a convex fillet weld as illustrated in Figure 6. Lower ductilities, albeit ample ductilities for many applications, are listed in the physical properties of Table 1. Considering the many structural units such as stairways and platforms to be found in a refinery there is a great field for E6012 electrodes.

Direct current and straight polarity are recommended for E6012 electrodes. This current condition combines with the quick soldifying properties of the deposit to produce welds of excellent appearance and absolute freedom from undercut. Furthermore E6012 electrodes may be used in all welding positions. Two outstanding reasons for the development of grade E6012 electrodes are the poor fit-up qualities and the fast deposit rates possible.

Poor Fit-Up Qualities

E6012 electrodes are sometimes known as either poor fit-up or general purpose electrodes. Oftentimes structures are assembled for welding without a perfect fit. Many electrodes become unmanageable where gaps must be bridged and the poor fit-up type is valuable as a result. Where the utmost in quality is desired, the poor fit-up electrode will not do. However the gap may be bridged and higher quality metal deposited afterwards. Where double butt welds are possible, the poor fit-up weld deposit may be chipped or gouged out before completing the weld.

Fast Deposit Rates

The quick solidifying attribute of the E6012 electrodes make them suitable for use in large diameters, 7/32-, 1/4- and 5/16-inch which are frequently used to produce good welds at high rates of speed. The quality of deposit from these larger electrodes in single pass welds is as good as that from the smaller sizes. Thus much work of satisfactory quality becomes possible in any application where E6012 electrode is usable. Current and electrode diameter combinations that will double the welding rate established with an E6010 electrode are not at all uncommon.

The last distinct type of welding electrode under consideration is E6020 or E6030 type. Very often there is one electrode that will do the work of both types and for this reason they will be considered as one. Therefore any reference to performanc of E6020 electrode should be understood to apply to E6030 electrode. Both will produce the concave fillets of Figure 7.

It would be difficult to find a pressure vessel or a pressure piping assembly of any size today that has not been fabricated in a shop using as much electrode material of E6020 type as possible. High speeds of deposit accompanied by the very best physical properties is the answer. But the weld deposits are restricted to the downhand positions or, at most, the horizontal fillet positions. In the latter position a maximum diameter limitation of ¼-inch has been established by practice.

However the use of positioners and other handling devices to make possible the application of all weld

FIGURE 7
Concave fillet made with a E6020 or E6030 electrode

metal in the flat position brings with it a consistency that cannot be equalled by any other manual-weld deposit. Perfect x-ray results are commonplace with weld metal from E6020 electrodes. Outstanding features of E6020 electrodes are extremely rapid deposit rates, perfectly sound welds and highest ductility values.

Rapid Deposit Rates

The high deposit rates are associated with the current carrying capacity of this type of electrode. Large diameters, 1/4- and 5/16-inch, may be used with currents running to 400 and 500 amperes. With

this great heat input sufficient thermal capacity must be present in the joint. Minimum thicknesses of ⅜- to ½-inch have been established for the best performance results with E6020 electrodes. By virtue of the fine performance with current values in the upper range these electrodes are known as "hot" rods in the welder's parlance.

Perfectly Sound Welds

An ideal balance between coating ingredients and fluid deposit leads to perfectly sound welds. The least manipulative skill is demanded by E6020 electrodes as is demonstrated by the fact that welders with slight training have been taught to make perfect test welds in an hour or two. A heavy slag blanket keeps the pool molten long enough for the gas to rise. This same slag blanket allows the solidified metal to cool slowly with a more definite normalizing of the crystal structure.

High Ductility Values

As may be seen from an inspection of Table 1, the greatest ductility as measured by elongation in a tensile specimen will be found in E6020 electrodes. This ductility is another function of the coating and type of deposit. Where the best possible combination of strength and ductility is needed, E6020 electrode types should be specified.

At this point it is well to mention that the 60 of the grade type refers to the minimum tensile strength in kips. (A kip is 1000 pounds per square inch.) Thus another group of electrodes possessing the same properties is available with a prefix 70 that signifies a minimum tensile strength of 70,000 psi in the stress-relieved state. With the exception of the change in tensile strength and slight modifications in ductility the two groups perform in an identical fashion.

Higher-strength electrodes are well adapted to the needs of both silicon-killed high-tensile steels and carbon-molybdenum steels which are finding ever more uses in refinery practice. Fortunately procedures established for the welding of mild steel can be carried over into the higher-strength field with little or no change. In some cases an extra precaution, preheating, is recommended but other than this the welding operations are parallel.

Three distinct classes of welding electrodes are available for refinery service. The first, or E6010, type is already well established. Possessing definite and well-known characteristics this electrode has been used for a multitude of welding problems. The only danger is that it may have been given wider application than was necessary.

The second, or E6012, type has been neglected in many refineries. Although a somewhat inferior quality must be acknowledged, there is a definite field for this electrode in rapid structural welding or for the bridging of poor fit-up assemblies. Where the qualities of this type are sufficient for the service, it should be given favorable consideration.

Finally the third, or E6020, type has been neglected to a considerable degree by the welding personnel in the refinery. Positioners are needed to get the utmost from this electrode. However the savings in welding costs and the consistent quality made possible by this electrode will more than pay for simple positioning equipment where the amount of welding maintenance work is considerable. Some refineries do their own heavy piping fabrication for new as well as repair installations. In this work they will do well to follow the lead of the foremost piping fabricators who have standardized on E6020 electrodes wherever such standardization was possible.

Oil in the War

A balance sheet study to show whence we have come and whither we go

Oil industry has learned that tanker sinkings and diversions spell more than a transportation calamity

BUSINESS as usual ceased to exist for the U. S. petroleum industry more than a year ago.

Since that time, the industry has operated under increasingly strict and complicated control, which has had for its fundamental purpose the utilization of the industry's facilities, effort, and talent for the most efficient possible furtherance of the national interest and safety.

Soundness of that purpose is beyond question. But it is well to know how well the purpose is being achieved. And in order to assure a direct course, continuing study and appraisal of results is essential.

The necessity for thus keeping watch over developments and for evaluating their significance is accentuated by the extreme complexity of the industry's economy.

The experience under artificial control, even up to this juncture, has been so involved and complicated that few men in the industry or in the regulatory agencies of the government thoroughly understand all that has happened, where the industry really stands, what its most serious problems are, and what difficulties are indicated for the future.

". . . private concerns cannot long continue to do what they cannot pay for." *Harold L. Ickes, Petroleum Co-ordinator, June 25, 1942.*

Nevertheless, a clear and widely disseminated understanding is necessary if war time control is to achieve the purposes for which it is intended. In an effort to contribute something toward the needed clear understanding and straight thinking in connection with present and prospective problems. Petroleum Refiner presents this analysis of problems now faced, and a study of some fundamentals of economics which need to be given particular consideration in connection with future control. Independents and majors alike have a stake in the problem.

HIGHER COSTS + LOWER VOLUME + ALTERED YIELDS + PRICE CONTROL = DISASTER!

L. J. LOGAN

THE fact that petroleum was the first major United States industry to be placed under governmental direction for national defense and war purposes is evidence within itself of the vitally important position this industry occupies in a war economy.

Because it is highly essential for the industry to function properly and efficiently today, as contemplated in the basic purpose of wartime control, there is a public as well as an intra-industry interest in its continuing health and soundness.

Consequently, there is necessity for ceaseless watch over the industry's condition, with the purpose of detecting and promptly remedying any disorders or maladjustments that might lead to serious impairment of strength and efficiency.

Such scrutiny at present is encouraging. There has been up to now a commendable cooperation of government with the industry, to the end that serious and complex problems have been satisfactorily dealt with, permitting the industry to provide an adequate supply of petroleum products for the Army and Navy, for war-goods manufacturers, for transportation of war-industry workers, and for at least the essential needs of civilians. Up to now, there has been, therefore, a fair degree of fulfillment of the fundamental purposes conceived in the wartime controls.

Situation Far from Perfect

Nevertheless, the functioning of the industry under the restrictions at this juncture remains far from perfect, under any conception of perfection. ***Although some of the major difficulties encountered have been surmounted, there remain others which have not been overcome and which tend to defeat the guiding purpose of keeping the industry in position to "deliver the goods."***

In fact, it is to be expected that the industry will not be "out of the woods" even if and when the currently remaining problems are solved. On the cotnrary, it may be anticipated that new problems will come up in steady succession, to test the ingenuity of all who influence the administration of the wartime control of the industry. Just as the nation's general situation will constantly and sometimes unpredictably change, so the oil situation will endlessly change and give rise to new problems. The satisfactory solution of the problems will require mutual understanding and cooperation of both industry and the government, as well as the straightest thinking that each can contribute.

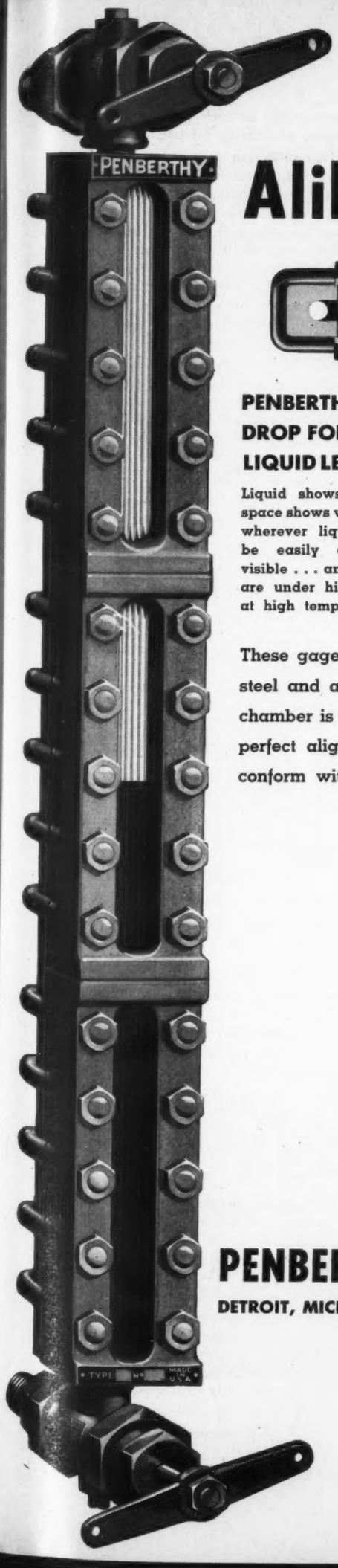
Axis Hit at Vital Point

The problems which have had to be faced up to now have been in large measure transportation and problems growing out of transportation difficulties, although there have been many others, including the necessity of carrying on drilling, production, and refinery operations with greatly curtailed supplies of materials and equipment and with diminishing manpower, the responsibility of providing new products required by the war, and the necessity of making production of established products fit war needs.

Precipitated by the Axis submarine campaign against American shipping at the middle of January, 1942, the transportation problem constituted within itself a severe test of the ability of the industry to carry out its functions. But the problem was made doubly formidable by being enmeshed in the price-control program, as petroleum had been placed under price ceilings in October, 1941, although general price fixing did not come until April, 1942.

Loss of many tankers and eventual virtual cessation of tanker shipments made it necessary for the industry to replace in so far as possible the normal, cheap water transportation to the East Coast by expensive rail, barge, and pipe line shipments, while obliged meanwhile to continue selling oils at the points of consumption at ceiling prices based on the low-cost transportation. Even tanker shipments became very costly—eventually more than three times the normal rates contemplated in price ceilings, and the industry also had to absorb those extra costs on the shipments that were maintained by water, until they were assumed by the government effective April 20.

Out of this general situation grew some of the most serious problems that the war has imposed so far, and while some of those problems have been wholly or partially solved, others remain as serious difficulties.



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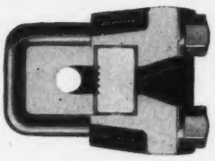

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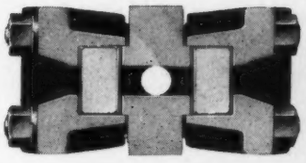

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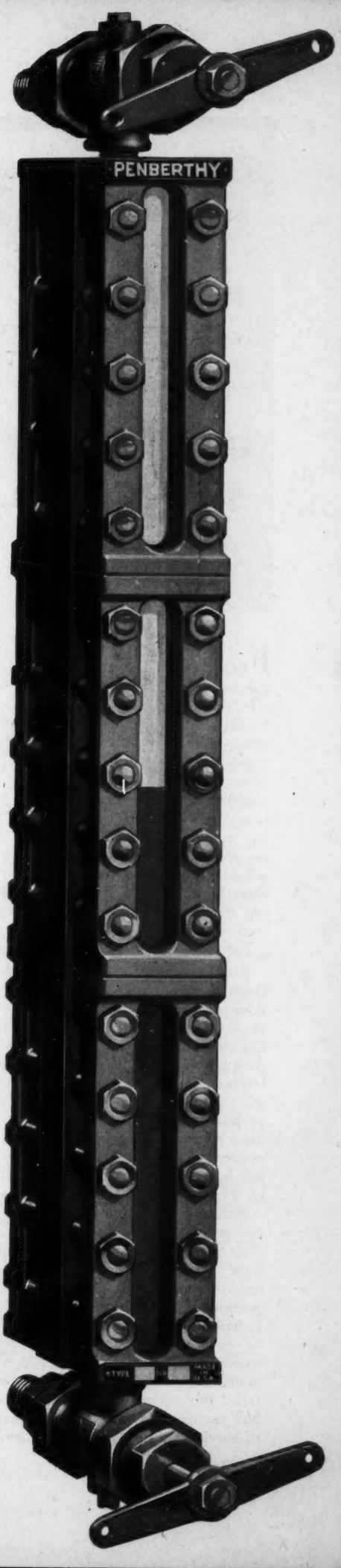


TRANSPORTATION CRISIS IS FELT FROM STRIPPER WELL TO SERVICE STATION

FROM the standpoint of the greatest number of people directly affected, outside and within the industry, the most far-reaching problem raised by the transportation shortage has been that involving the sharp reduction in volumes of petroleum moved out of the Southwest to the East Coast. The question of how well the war-time control has maintained the volume of oil moving through is the valid interest of the whole nation as well as the many people directly affected, inasmuch as supplying military requirements, war-production needs, and essential civilian demand is involved.

Aside from national interest involved, there is the wide interest of the millions of people of the Eastern States in sacrifice of normal use of gasoline and other oils. Within the oil industry itself there is a far-reaching interest in the situation, which has left only sharply curtailed volumes of business for all branches of the industry from well to service station. The reduced volume of oil movement has left less revenue for crude oil producers of Texas, New Mexico, Louisiana, and Arkansas and diminution of their financial strength to continue producing oil. East Coast and Gulf Coast refineries have had to curtail production of products in some instances to as little as 30 percent of capacity, with the result that remaining operations are less profitable or even unprofitable as evidenced by shutting down of some plants. At the consuming end of the chain, the curtailed movement of petroleum products has involved closing up of thousands of service stations in the East and loss of opportunity for profit by many others.

The acid tests of the seriousness of these results of the lower volume of oil movement to the East are whether oils have failed to reach the Army, Navy, war industries and essential civilian consumers in adequate quantity, and whether the industry's ability to continue serving the nation has been impaired.

Fortunately, the answer generally in each case is no, and therefore, in the main, the war-time control shows no apparent shortcoming on this score.

However, the record is not entirely unblemished, as there have been complaints that Eastern war-industry workers were having difficulty in obtaining sufficient gasoline to go to their work. Gasoline rationing under the temporary system failed to hold down demand as expected, and all brought into the district was used, besides which it was necessary to cut into already sub-normal stocks. Meanwhile, there were inequalities involved for consumers, and as stated, war production may have suffered to some extent. Better results through the permanent rationing system, effective July 22, are hoped for, although actual effects remain to be seen. It is anticipated that use in addition to basic rations can be cut down under the new system. But it is noteworthy that registrations for coupon books resulted in surprisingly high percentages of applications for supplemental rations.

Gasoline Use to Be Further Tightened

On the basis of the situation and outlook at the close of July, it appeared quite possible that gasoline rationing would have to be tightened up to such extent that it would be extremely stringent before the end of the summer, involving possibly virtual elimination of civilian use except strictly essential requirements.

That possibility looms in consideration of the fact that provisions must be made for moving to the East sufficient light fuel oil to heat during the fall and winter the many factories, office buildings, homes, and apartment buildings that depend on oil as fuel, aside from continuing to supply heavy fuel oils for war industries.

During the spring and summer it has not been possible to achieve a normal build-up of Eastern stocks of heating oil, and consequently, there is a definite threat of shortage. And inasmuch as heating oil is relatively more essential than gasoline, it is indicated that henceforth, gasoline consumption will have to be scaled down enough to reduce the danger of a serious shortage of the heating fuel. The pinch on gasoline use is expected to be accentuated after September, because of heavy railroad traffic as well as opening of the season of heating oil use.

In connection with the curtailed volumes of oil movements to the East Coast, no particular fault can be found with the war-time direction of the industry's affairs from the standpoint of efficient marshalling of available physical facilities. On the contrary, commendation is due for the results that have been gotten out of facilities and materials. With comparatively small use of new materials and equipment, shipments have been stretched far above the normal capacity of facilities employed. And in so far as it has been possible to provide new pipe lines and other transportation facilities, they have been provided.

However, it is contended in some quarters that war-time control is failing to achieve a maximum amount of effectiveness in coping with the curtailment of oil movement into the Eastern States, in that artificial barriers are allowed to interfere with shipments, besides the physical handicaps that are involved. ***It is maintained, specifically, that the volumes of oils moving through are held down substantially below physical potentialities by reason of the effect of price ceilings in causing financial losses.***

This opinion is held by some oil company executives and economists who have a first-hand knowledge of facilities and the circumstances involved, and in so far as it is correct, OPA is exerting a restricting effect to which increased and prompt attention is due.

Why More Oil Is Not Moved

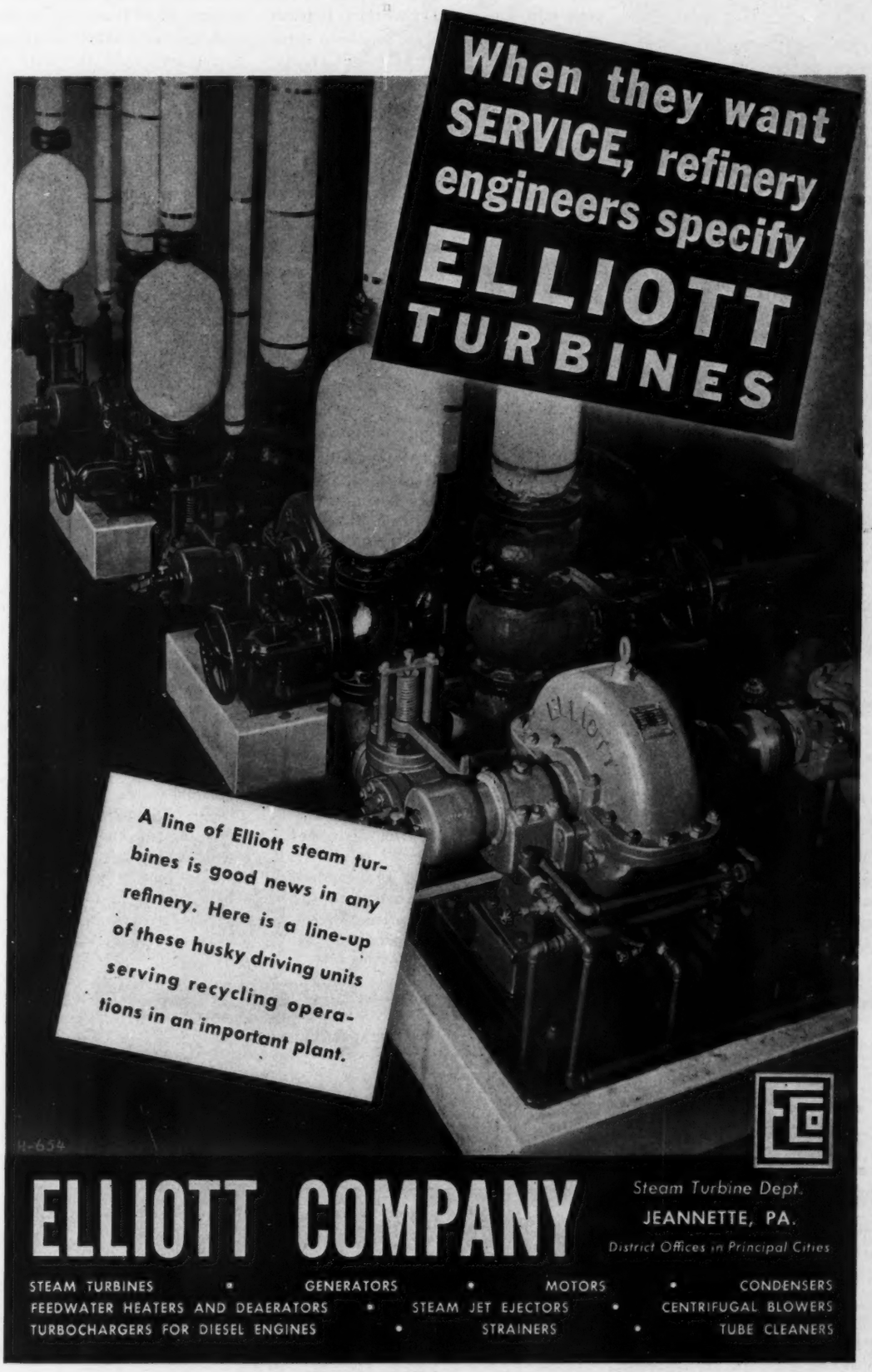
Intricately but directly involved in this failure to lay down more oils on the East Coast have been particularly two factors:

1. The inhibition against shipping oils into OPC District 1 (East Coast area) from District 2 (Middle West and upper Mid-Continent), with existing control making those oils not only uncompetitive with Gulf Coast and other oils farther away but even a source of out-of-pocket loss when shipped to the East.

2. The inhibition against determined effort to increase movement from all sources, with war-required changes in refinery yields unrecognized in price ceilings and therefore causing serious monetary loss.

Both of these matters, prohibitive buying of oils in District 2 and monetary loss in providing necessary refinery yields, have been recognized by OPC, and they have been pointed out to OPA, which in turn has had them under advisement. Relief now is definitely assured in the first matter, but there has not yet been any official action in connection with the latter.

[*Continued on next page*]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MORE OIL CAN BE MOVED IF EXISTING CONTROL CAN BE REVISED

IN THE first instance, existing control has glaringly discouraged the shipment of oils into District 1 from District 2 by making higher-priced oils from the eastern portion of District 2 uncompetitive with the lower-priced oils brought in from points farther west. For transportation costs have been, in effect, the same in both instances, with any extra shipping costs above normal tanker rates being absorbed in the increases authorized in Eastern ceiling prices. There has been no encouragement for an oil company to bring into the East Coast area residual fuel oil bought for $1.68 a barrel in Indiana and Illinois, in competition with material available for 95 cents in Oklahoma and Kansas and for 85 cents on the Gulf Coast, with all extraordinary transportation cost into District 1 absorbed in each instance. Similarly, there has been naturally a reluctance to buy even in Oklahoma-Kansas as against the Gulf Coast. In fact, any purchase above the Gulf Coast price has embodied cost above that contemplated in price ceilings. Regardless of where the oil comes from, its net market value in the East Coast district is only on the basis of Gulf Coast price plus normal transportation cost from the Gulf Coast. The present ceiling price for which residual fuel oil can be sold, in tank cars, in District 1 is $1.80 a barrel, but the net market value is only $1.35, after 45 cents is taken out to apply against extra transportation costs into the district; and when the normal transportation cost of 48 cents a barrel, as contemplated in the price ceilings, is covered, there remains only 87 cents a barrels to cover the cost of the fuel oil itself. That amount is sufficient to make purchases on the Gulf Coast, but it is only half enough for buying in Illinois and Indiana; and a loss of 81 cents a barrel is indicated on shipments made from the latter area. Stated in another way, the oil company has had to pay $1.68 for Indiana-Illinois residual fuel oil and pay the normal freight of 48 cents a barrel to the East Coast, incurring a total net cost of $2.16 per barrel for the heavy fuel oil delivered in tank cars, although obliged to sell it at a ceiling price of $1.80, which netted a market value of only $1.35 after deduction of the 45 cents that went into the transportation pool to cover the war-induced extra transportation costs into the region. Corresponding price differentials for other petroleum products, as between the Middle West, Mid-Continent, and Gulf Coast, similarly discouraged shipments of those oils from District 2, making net market value on the East Coast less than the cost of bringing it in.

Actually, the industry has been shipping the higher-priced oils of District 2 into District 1 in large volume, although without any definite assurance of being compensated for the extra cost involved. Such extra cost is estimated to have amounted to almost $10,000,000 in the first six months of this year, and on the basis of indicated shipments for the future, a loss possibly three times that amount, or at the rate of about $5,000,000 a month, might have been involved for the last six months of the year, in absence of remedial action.

OPA finally has worked out a correction of this situation, with aid of the Reconstruction Finance Corporation, although there has been no indication that back losses will be compensated.

Jesse H. Jones, Secretary of Commerce, last week announced that Defense Supplies Corporation, subsidiary of the RFC, effective August 1, would remove the price barrier to purchasing in the Middle West by paying "the additional costs" of buying there instead of the Southwest. Details were not given at that time as to how the matter would be handled. But it was believed that DSC would buy crude or products in the Middle West at ceiling and market prices of the district and re-sell them at points of purchase to distributors of the East Coast region at Gulf Coast prices; or else that DSC would buy in the Mid-West at established prices, transport oils to the East, and sell there at OPA ceilings, in either case absorbing the loss involved.

Calculations Showing Effect of (1) Curtailed Crude Runs and (2) Decreased Crude Runs

(Table is explained in accompanying text)

	CASE 1 Bureau of Mines Report—Last Half Year 1941 Ceiling Prices as per Order No. 88, Feb. 2, 1942					CASE 2 30 Percent Decrease in Crude Run Same Yields and Prices as Case 1				
	Yield		Prices			Yield		Prices		
	Barrels Made	% Crude	Cents a Gal.	Dollars a Bbl.	Gross Value, Dollars	Barrels Made	% Crude	Cents a Gal.	Dollars a Bbl.	Gross Value, Dollars
Gasoline (72-74 Octane)	95,492,000	43.1	5.75	$2.41	$230,135,720	66,844,000	43.1	5.75	$2.41	$161,094,040
Kerosine	16,122,000	7.3	3.87	1.63	26,278,860	11,285,000	7.3	3.87	1.63	18,394,550
Distillate Fuel	36,481,000	16.5	3.75	1.57	57,275,170	25,537,000	16.5	3.75	1.57	40,093,090
Residual Fuel	51,952,000	23.5	....	0.85	44,159,200	34,906,000	22.6	....	0.85	29,670,100
Navy Special Fuel	.....	....	....	....	.....	.....	....	....	....	.....
Still Gas	14,193,000	6.4	....	0.85	12,064,050	9,935,000	6.4	....	0.85	8,444,750
Other Products	4,866,000	2.2	3.00	1.26	6,131,160	4,866,000	3.1	3.00	1.26	6,131,160
Loss	2,213,000	1.0	....	....	.....	1,549,000	1.0	....	....	.....
Total	221,319,000	100.0	....	....	$376,044,160	154,922,000	100.0	....	....	$263,827,690
Gross Return/Barrel Crude Run	.....	....	....	$1.70	.....	.....	....	....	$1.70	.....
Crude Cost	.....	....	....	1.38	$305,420,220	.....	....	....	1.38	$213,792,360
Operating Cost	.....	....	....	0.26	57,542,940	.....	....	....	0.32	49,575,040
Gain or Loss	.....	....	....	**0.06**	**13,081,000**	.....	....	....	**0.00**	**460,290**

Tube-Turn Welding Fittings are built to *stand the gaff* at the turns!

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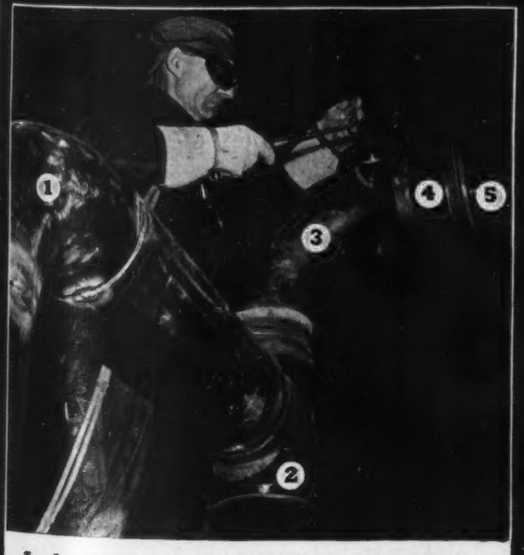

In the above assembly, Tube-Turn welding fittings are speeding up the erection schedule and permitting a compactness of piping impossible if handled any other way. Also, their uniform wall thickness makes aligning and welding quicker and easier. Note the five Tube-Turn fittings in this small piping section: (1) a 90° elbow; (2) a tee; (3) another 90° elbow; (4) a lap joint welding nipple; (5) a lap joint flange.

It's tough enough to hang on the board when a speed boat is making sharp turns along a zig-zag course, but add the perilous sport of water jousting—and the *danger at the turns* is doubled!

Extra punishment occurs *at the turns* in industrial piping systems, too. That's why it is safer practice to *weld piping with Tube-Turn fittings.* Tube-Turn fittings provide maximum strength, prevent leakage permanently, and practically eliminate maintenance costs.

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ALTERED YIELDS BRING INCREASED LOSSES AND LOWER OUTPUT

THE second matter mentioned as tending to impede the volume of movement of oils into the East Coast district, that of monetary loss involved in providing needed refinery yields under available prices, involves particularly the circumstance that ceiling prices on fuel oils discourage bringing in more of those oils or their equivalent in crude oil, in line with the potential special demand for those oils.

The industry is asked to make more fuel oil and to bring more into District 1, larger yields of the fuel oils being sought in Districts 2 and 3 as well as in District 1. These results are calculated to be achieved without material change in the volume of crude runs to stills, by sacrificing a substantial proportion of the normal yields of gasoline, in view of curtailed demand for that product. The weakness of the concept, as sponsored up to now, is that the industry is obliged to sustain serious losses in order to provide the increased volumes of fuel oils that are desired. As in the case of bringing in relatively expensive oils from District 2 at a loss because they are urgently needed, the industry actually has leaned over backwards to make more fuel oils available by stepping up yields of them at refineries; but it has done so at its own expense, in the form of reduced revenue involved in lowering yields of gasoline. It does not require a very great diversion of the refiner's production from gasoline to fuel oil to cause loss on operations, in the absence of compensating increases in the price of fuel oil. Aside from motives of patriotism and willingness to make reasonable financial sacrifice, therefore, there is no inducement to increase yields of fuel oil and reduce yields of gasoline, and even those motives soon reach the limits beyond which there is serious operating loss. Official figures show that refiners have substantially changed yields as desired, but it hardly can be doubted that more fuel oils would be produced and somehow transported to the East Coast if prices were such as to make it possible to achieve those results without loss. The result that is to be expected with prices causing loss, in contrast, is for the refiner to run only whatever amount of crude is necessary to provide the gasoline that he can sell, without any effort to step up the amount of fuel oil that accumulates in the process of meeting the gasoline demand.

Although Indiana-Illinois fuel oils are due to be on a competitive basis with Gulf Coast oils henceforth, as brought out above, there is no assurance that they will be produced in increased volume in order to make increased shipments to the East Coast possible. For the prices needed for drawing forth larger output of those oils, as such, are lacking. Given adequate prices, Middle Western refiners would utilize to the fullest extent possible the pipe-line and other transportation facilities for bringing in crude to their plants from fields in District 2 and District 3 and would increase fuel oil production by stepping up runs to stills, even if it became necessary meanwhile to reduce yields of gasoline because of curtailed demand for that product.

Refineries of the Indiana-Illinois-Kentucky district have a rated capacity of 784,000 barrels daily, but they are being operated at rates only around 700,000 daily, or at somewhat less than 90 percent of potential, although local crude production is around 330,000 barrels a day. Last October they actually averaged a crude input of 735,000 barrels daily.

Oklahoma-Kansas-Missouri refineries are rated at 418,000 barrels daily but are being operated at only 335,000 to 350,000 daily, or 80 to 85 percent of capacity, although crude production is averaging about 640,000 barrels daily, providing around 300,000 for Middle Western plants.

The Indiana-Illinois and Oklahoma-Kansas plants together have capacity of 1,202,000 barrels of crude daily but are processing only about 1,050,000 daily, or 150,000 less than potential. On the present basis of refinery runs, crude production of the combined districts must be supplemented by about 80 000 barrels daily from North Texas and other areas, and those districts probably would have to supply the bulk of the 150,000 barrels a day more that would be needed to boost the Middle Western and upper Mid-Continent plants up to 100 percent of capacity. However, the networks of pipe lines in Texas and adjacent states and through Oklahoma offer possibilities for increased movement of crude into the District 2 refining centers.

Better prices for fuel oil on the East Coast, where it is urgently needed, could be expected inevitably to stimulate in all supplying districts increased efforts to get it there.

In general, moreover, the same thing can be said of other petroleum products and also of crude oil. In so far as any oils may be allowed to have a greater market value on the East Coast, and correspondingly in the districts that supply that large consuming region, the resourcefulness and effort to put them there will be increased.

Conversely, in so far as the market value of any oils in the East Coast

Reduced Gasoline Yield in Texas and Louisiana Gulf Coast

	CASE 3 30 Percent Decrease in Crude Run 20 Percent Decrease in Gasoline Yields Same Prices as Case 1 Except*					Suggested Price Ceilings To Offset Total Loss in Case 3		
	Yield		Prices			Prices		
	Barrels Made	% Crude	Cents a Gal.	Dollars a Bbl.	Gross Value, Dollars	Cents a Gal.	Dollars a Bbl.	Gross Value, Dollars
Gasoline (72-74 Octane)	53,475,000	34.5	5.75	$2.41	$128,874,750	6.00	$2.52	$134,757,000
Kerosine	11,285,000	7.3	3.87	1.63	18,394,550	4.75	1.99	22,457,150
Distillate Fuel	25,537,000	16.5	3.75	1.57	40,093,090	4.25	1.78	45,455,860
Residual Fuel	33,915,000	21.9	....	0.85	28,827,750	....	1.05	35,610,750
Navy Special Fuel	15,000,000*	9.7	....	1.05*	15,750,000*	....	1.26	18,900,000
Still Gas	9,295,000	6.0	....	0.85	7,900,750	....	0.85	7,900,750
Other Products	4,866,000	3.1	3.00	1.26	6,131,160	3.00	1.26	6,131,160
Loss	1,549,000	1.0	....	....	.....	....	....	.....
Total	154,922,000	100.0	....	....	$245,972,050	....	....	$271,212,670
Gross Return/Barrel Crude Run				$1.59	.....	....	$1.75	.....
Crude Cost				1.38	$213,792,360	....	1.38	$213,792,360
Operating Cost				0.31	48,025,820	....	0.31	48,025,820
Gain or Loss						....	**0.06**	**9,394,490**
Additional loss of 154,922,000 bbls. x $0.06				$0.10	15,846,130	Decrease in indicated net return		3,686,510
					9,295,320			
Total Loss			....	....	.....	.....	.....	.....
					25,141,450			

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region and supplying districts may be arbitrarily or artificially held down, the inducement for making them available will be reduced, and consumers will be deprived of oils they need, while producers and refiners of the Southwest beg for markets.

As previously indicated, refiners in all districts are discouraged from making needed adjustments of refinery yields into conformity with war-time requirements for the individual products because existing prices for the normally secondary products do not permit the changed yields except at financial loss. The problem of effecting needed changes in yield now is made doubly difficult, moreover, by the fact that volume of petroleum handled is subnormal, leaving less revenue to cover operating costs.

In actual instances, many refiners of the Gulf Coast and East Coast districts would be barely able to break even on current curtailed operations even if they were continuing to take normal yields of gasoline, while any superimposing of reduced gasoline yields nad increased fuel-oil yields on the reduced volumes of plant production results in operating loss.

Industry Takes it on the Chin

Despite losses involved, the industry has to some extent reduced gasoline and increased fuel-oil yield, as needed by the nation and directed by the government. However, it is not reasonable or practical to ask the industry to go further in this regard or even to continue results already achieved without provisions for compensation for the loss involved. And OPA has recognized this fact. However, somewhat of a stalemate now exists. The agency apparently would be willing to provide compensation for substantially changed yields, but is reluctant to take any action until there is more justification for it in the form of statistics showing sharper changes in yields and maintenance of such yields for a longer period. But at the same time, the industry is reluctant to go farther than it already has done, sustaining heavier losses, without greater assurance of compensation.

Case Studies

In connection with this problem, considerable study has been carried out, and calculations have been made as to the profit or loss involved in the various districts under normal conditions and under changed conditions with respect to war-time runs to stills and desired refinery yields. (See table on pages 14 and 15.) From these calculations the industry has suggested, through committees, prices that would be needed to avoid operating loss and to afford reasonable profit while taking from the barrel of crude the proportions of the various products regarded as necessary.

Such figures that were worked up for the Texas-Louisiana Gulf Coast district showed that in the last 6 months of 1941, on crude runs of 221,319,000 barrels, the actual yields of the different products were such as to provide the refiner a gross return of $1.70 per barrel of crude run, on the basis of ceiling prices scheduled in OPA price order No. 88, February 2, 1942. Deduction of crude cost of $1.38 per barrel and operating cost equivalent to 26 cents per barrel indicated a margin of 6 cents per barrel. Those yields and that volume of runs to stills constituted the conditions on which the ceiling prices were based.

What Happens When Runs Are 30% Lower

However, much less satisfactory results were indicated by applying those same ceiling prices to the products manufactured in an assumed case in which yields of the different products were normal, or as before, but with runs to stills down 30 percent, a situation comparable with that which actually developed on the Gulf Coast after commencement of the submarine campaign. Under these reduced runs, the indicated gross return to the refiner per barrel of crude run was $1.70, or the same as before, in reflection of same prices and same yields except an insignificant one in minor products. Likewise, the deduction for cost of the crude was unchanged at $1.38 per barrel. But operating cost applicable to each barrel of products was up to 32 cents, in reflection of inability to lower expenses in proportion to decreased total gross revenue on the curtailed operation basis—an increase of 6 cents a barrel. Inversely, remaining profit dropped 6 cents a barrel, or to zero.

Now Look at Lower Runs and Changed Yields

Then the same ceiling prices were applied to products manufactured in another assumed case in which runs to stills again were down 30 percent from rates in the latter half of 1941, while yields of products were adjusted in accordance with indicated war time requirements. The adjustments were principally a 20-percent decrease in gasoline yield (from 43.1 percent of the content of the barrel to 34.5 percent) and diversion of the crude so saved almost wholly into the making of residual fuel oil and the allied Navy special fuel, indicating the combined yields of 21.9 percent of residual fuel oil and 9.7 percent of the Navy fuel instead of a 22.6 percent of residual fuel oil, former

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equivalent of both. In this case, the indicated gross return to the refiner per barrel of crude run was only $1.59, or 11 cents less than in either of the two previous cases, in reflection of the smaller proportion of gasoline made and the larger proportion of fuel oil, with the latter having much less market value. No saving on crude cost was possible, with the ceiling price as before at $1.38 a barrel, while it similarly was not possible to save more than 1 cent a barrel on operating cost (31 cents a barrel against 32 in the second case), with that small saving due to elimination of cracking and other gasoline-making expense. Under these conditions, market value of products failed to cover cost of crude and operating cost by 10 cents a barrel, indicating a loss of that much on each barrel of crude processed, instead of the 6 cents a barrel profit under conditions of the latter half of 1941. While the out-of-pocket loss was 10 cents a barrel there was also an additional loss of 6 cents a barrel on each barrel processed, representing profit contemplated in price ceilings but not possible under changed operating conditions. The total of those two items of loss was thus 16 cents a barrel, representing the amount by which the $1.59 gross return per barrel of crude run failed to cover costs and profit as contemplated in price ceilings.

Adjusted Prices Suggested

Finally, adjustments of prices were suggested which would eliminate that 16-cent loss per barrel, or bring in the above indicated $1.59 gross return plus the 16 cents, or a total of $1.75 per barrel, which *would* cover costs and margin as contemplated in the price ceilings.

The suggested Gulf Coast refinery price ceilings thus determined were as follows: gasoline, 72-74 octane, 6 cents a gallon, instead of 5¾ cents as in Order 88; kerosine, 4¾ cents instead of 3⅞ cents; distillate fuel oil, 4¼ cents instead of 3¾ cents; residual fuel oil, $1.05 a barrel instead of 85 cents; Navy Special Fuel, $1.26 instead of $1.05; still gas, unchanged at 85 cents a barrel; and other products, also unchanged at 3 cents a gallon or $1.26 a barrel.

These prices would afford the gross return of $1.75 per barrel of crude run and provide profit of 6 cents a barrel on the crude handled. However, because of the assumed 30-percent decrease in crude runs to stills, indicated net return or total profit similarly would be down 30 percent.

These suggested price adjustments thus were meant strictly as compensation for changed yields, and did not involve any compensation for the 30-percent indicated loss of profit due to

4

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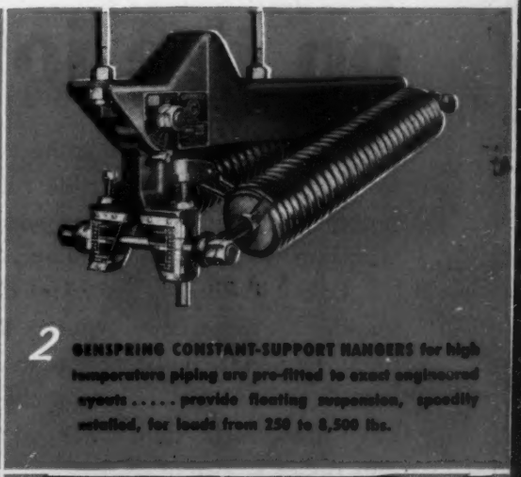

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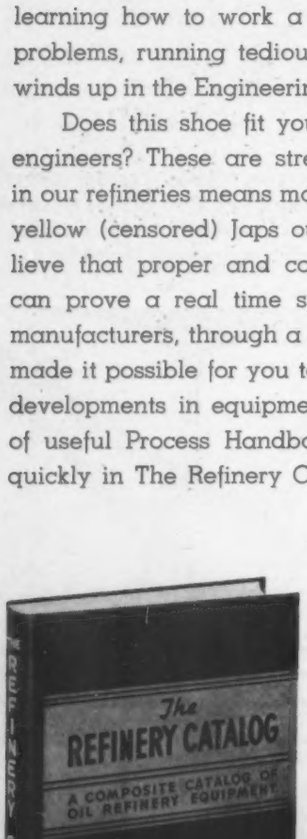

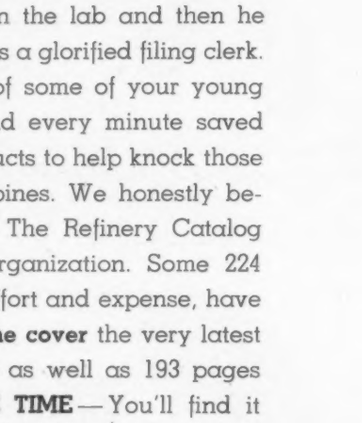

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the war-induced curtailment of runs to stills or volumes of business.

Details on the above calculations are given in the table on pages 102 and 104.

On the basis of the calculations for the Gulf Coast, the refiners of that district alone, holding 28 percent of the refining capacity of the United States, would be penalized to the extent of $50,000,000 a year in actual out-of-pocket loss and failure to make normal profit on crude handled by reason of curtailed runs to stills and adjustment of refinery yields to needed proportions.

East Coast Comparison

Similar calculations also were made for District 1 (East Coast), and they indicated that the corresponding loss for that district, holding 15 percent of the nation's plant capacity, would be at the rate of $32,000,000 a year. For that district, it was calculated that the desired 20-percent cut in gasoline yield and proportional increase of residual fuel oil yield would result in a decrease of 19½ cents per barrel in normal realization on about 450,000 barrels per day of crude charged to stills in the region —a recent level of operations, when plants were operated at 63 percent of their rated capacity of 714,000 barrels daily. The industry actually is sustaining a substantial part of that loss by reason of having shifted yields in the desired directions, although not as far as desired. In the last 6 months of 1941, the district was taking a yield of 37.63 percent of gasoline and 21.3 percent of residual fuel oil, and as early as May, 1942, had cut the gasoline yield down to 32.93 percent and raised residual to 26.49, although a full 20-percent reduction of gasoline yield would cut that product to 30.10 percent of the content of the barrel of crude.

Calculations for District 2 (Middle West and upper Mid-Continent) assumed continuance of runs to stills at about the same rates as in 1941, as the region retains sources of supply and markets, but showed that changes in yields would cause a drop of 11¼ cents a barrel in realization on products. On the basis of the 395,000,000 barrels of crude run to stills in 1941, the loss entailed would be, therefore, approximately $44,000,000 a year. In that district, gasoline yield was 52.2 percent in the last 6 months of 1941 and residual fuel oil yield 18.2 percent, and adjustment to desired levels would require 41.8 percent gasoline, 23.8 percent residual fuel oil, and 10.5 percent distillate fuel, it was figured.

The difficulties that the industry encounters in changing yields are readily understandable when it is considered that the industry is being asked, in effect, to make a substantial part of its raw material into relatively cheap fuel

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oil instead of relatively valuable gasoline without compensation for doing so. In making the fuel oil it is turning out a product less valuable than the crude from which it is derived and one which has always been worth only 30 to 50 percent as much as the average value of all products. In giving up output of gasoline, it is sacrificing a product normally worth around 150 percent of the average realizations for all products and worth three times as much as the heavy fuel oil.

Decrease in Yield Is Difference Between Profit and Loss

Decreases of around 15 cents a barrel in total realization for products, such as are involved in the needed changes of yield, represent a decline of only around 7 percent in gross income; but while that may appear inconsequential, it means the difference between moderate profit and serious loss, and shows what small margins the refiner operates on and what real values he gives. The refining industry charges the public only about 1 cent a gallon for all that it provides and does, including use and wear of equipment and out-of-pocket costs for labor, fuel, utilities, chemicals, supplies, and maintenance materials. Changes in yields that are now desired may cause decline in gross income within a month equivalent to the refiner's normal return on investment for several months. The results that were achieved in the latter half of 1941, under yields then obtained, were about normal, or slightly under normal, it should be pointed out. For an 8-percent return on net refining investment figures out to about 7 cents per barrel of crude run to stills, and that is about an average return, although variations above or below that figure have been common.

In so far as the industry has been compensated for war-time losses in its operations up to now, two remedies have been employed: (1) assumption of the costs of war-risk insurance on tanker shipments by the War Shipping Administration, and (2) authorization by OPA of increases in prices of oils in the East Coast district. Likewise, two similar methods have been considered by the government to eliminate losses involved in changed yields, namely, (1) price adjustments, or (2) payments made by the government to the industry to cover monetary loss involved in changing the yields.

As between the two methods of stopping the losses for the industry, it has been suggested that price revisions appear more practical, even though the uniform prices which would be necessary would differently affect different refiners, in accordance with their operating circumstances and the extent to which they actually adjusted yields toward essential levels. The problems raised would not be insurmountable, it is believed. Relief through payment of compensation on the other hand, would involve definite dollar payments, whereas losses sustained would be difficult or impossible to measure with the accounting exactness that the method would call for. When the East Coast price increases of June 29 were scheduled to compensate the industry for extra transportation costs, it was thought that those increases might stand in the way of the price-adjustment method of stopping losses involved in changed refinery yields. But inasmuch as it has been indicated subsequently that RFC would begin absorbing the extra transportation costs and thereby remove the need for increased prices for that purpose, the way apparently was left clearer for using price adjustments to solve the changed yields problem. Consequently, the prospect loomed that instead of completely rescinding the price increases heretofore authorized, OPA might only partially cancel them and leave part of the increases in effect to take care of the higher costs involved in changed yields, as well as to compensate the industry for the several large losses sustained in the past.

Dollar Payment Practical

It was stated by some interested parties, in this connection, that the dollar payment method of relieving the industry of losses on transportation is a very practical solution for that problem, inasmuch as definitely determinable extra shipping costs are involved, and inasmuch as payments by the government would represent payment by all the people of the extraordinary shipping expenses brought about by the war, for which no particular section of the country is responsible.

The minor problems which would be involved in handling the matter of changed yields through price adjustments include that of appraising effects of production of special products for war use and that of recognizing the differences in effect of changed yields on different refiners. For some refiners, losses involved have been offset to some extent by temporary acquisition of new markets; while for other refiners, the losses involved in changed yields have been accompanied by losses of substantial portions of normal markets. However, these matters could be satisfactorily worked out, it is confidently felt. Varying effects on different refiners would to some extent disturb competitive relationships, and to assure proper maintenance of competition within the industry, it might be found necessary or desirable to supplement the control through prices (by OPA) with control of volumes of production and movement of products (by OPC). Such double control would assure a competitive basis of supplying products not meeting the external competition of products of other industries, while oils meeting such external competition necessarily would be in any event on a properly competitive footing. By reason of the competition so maintained, from within and without the industry, there would be avoided any consequential violence to the national objective of holding prices in hand.

Urgency of the need for prompt relief for the industry from losses in connection with refinery yields is emphasized in the belief that it is imperative for the refining division to be kept in position to maintain efficient production of the petroleum products that will be essential for winning the war. It is pointed out further, that the refining branch faces heavy obsolescence of equipment, because of technical improvements that the war is bringing, and that the industry will have to be kept financially strong if it is to be able to perform its responsibilities of supplying needed oils in the reconstruction period after the war.

In connection with the above discussed artificial barriers to providing larger volumes of oils in the East Coast district, the question naturally arises as to whether it would be possible, even if they were removed, to substantially increase movement, with the physical facilities available.

Physical Barriers Can Be Overcome

Traditionally guided by the motto, "It can be done," men of the industry who are struggling with the present difficulties confidently believe that physical barriers to increased shipments could be largely surmounted. They think that the artificial barriers are definitely the most important impediments.

Furthermore, they lay heavy emphasis on the importance of removing those artificial barriers and thereby increasing volume of oil movement, contending that stepping up of the movement would cumulatively contribute toward solution of existing problems. Lack of larger volume of business accentuates seriousness of the current difficulties, making it impossible for the industry to offset such losses as those on changed yields by economies that might be achieved under large-volume operations. Conversely, minor or even substantial losses might be absorbed without serious consequences if the industry were doing greater volumes of business. The industry's whole economy is based on mass production and large volume of busi-

ness, it is pointed out, and when volume is restricted, the whole plan of operation is disarranged.

There are no definite physical limits to oil shipments across the United States, it is contended, the possible volumes being dependent primarily on the amount of effort put forth to achieve increased movement.

Pressed for suggestions as to remaining measures that could be taken to step up movement in the absence of artificial barriers, representatives of the industry declare that materially greater movement could be gotten out of existing tank cars, tank trucks, and pipe lines, particularly products lines. Attention is called to the fact that only 62,000 tank cars were used in delivering the recent peak movement of 788,500 barrels daily of oils into the East Coast District, whereas the railroads have asserted that they could handle 75,000 cars. Making use of the latter number would constitute a 20-percent increase in the tank car movement, or an expansion of 165,000 barrels in daily deliveries. The additional tank cars could be released for this use by transfer out of other districts and substitution in those areas of increased tank truck use and greater use of products pipe lines. Tank trucks currently are called upon to make deliveries within a radius of 100 miles of refineries, but there is nothing sacred about that figure, and trucks might release more tank cars by taking care of deliveries within a radius of 200 miles or similar distance. Furthermore, men of the industry insist that a much greater daily average movement of oil is possible with tank cars now in service; that the cars are moving at an average rate of only 10 miles per hour, whereas it is not unreasonable to ask for a considerably faster movement. Even the present rate would not prevail, it is stated, if there had not been special effort to achieve it, as the railroads used to get only about 25 miles per 24-hour day out of freight cars as a whole, while the rate even now probably is only about 30 miles a day. Increased shipping of oils in trainload lots, now being actively sought, offers important possibilities for larger overland movement, eliminating waste of time in rounding up cars at points of origin and dropping off of individual cars or groups of cars at points of destination.

The contentions that substantially increased shipments would be physically possible are supported by actual experience lately in planning and executing numerous measures for stepping up deliveries, in cooperation with OPC. Those steps, incidentally, represent more of the initiative taken by the industry toward alleviating the difficulties raised by the war, without definite assurance meanwhile of being compensated for costs and monetary losses involved.

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SAE to Hold Series of Technical Meetings

A series of technical meetings designed to concentrate engineering talent on numerous problems related to the design and manufacture, operation and maintenance, of mechanized war equipment has been scheduled by the Society of Automotive Engineers.

The sessions, held at Los Angeles, Detroit and New York for the convenience of engineers and to relieve transportation facilities, will augment the hundreds of committee meetings continually being held by the society to facilitate the cooperation of automotive engineers with governmental and military agencies in essential war work.

A West Coast Transportation and Maintenance meeting, to be held in the Biltmore Hotel at Los Angeles, August 20 to 22, will be concerned particularly with the maintenance of motorized equipment. It is expected that "Army Day" will be a feature, and that Army representatives will participate in the discussions.

The society's National Aircraft and Production Meeting and Aircraft Engineering Display will be held October 1 to 3, also in the Biltmore Hotel at Los Angeles. Subjects to be discussed include aircraft engine performance, oil coolers, various types of welding, operation and maintenance of aircraft in foreign fields, and plywood and plastic construction. Exhibits of and reports on captured Japanese and Nazi planes, engines, parts, and accessories will familiarize American engineers with enemy engineering practice.

A National Fuels and Lubricants Meeting will be October 22 and 23 in the Tulsa Hotel, Tulsa. Both technical and general sessions will be held. One session will be given over to a debate between student engineers from two universities. Subjects tentatively scheduled for consideration include crankcase-oil stability, bearings and corrosion, and new methods for recording and evaluating piston skirt deposits.

The society will hold a War Production-Engineering Meeting and Engineering Display in the Book-Cadillac Hotel at Detroit, January 11 to 15, 1943, replacing its 1943 annual meeting with this specialized war event. Development of the program, now in the formative stage, will be governed largely by the needs of the war program.

Safety Congress Will Be Geared to War

Instead of the customary program of five days, the thirty-first National Safety Congress and Exposition in Chicago, October 6, 7 and 8, will be confined to three days. This is part of the effort to "meet travel restrictions and other war conditions." No important function of the meeting will be omitted. Sessions have been rearranged and there will be night activities.

All strictly entertainment features have been omitted from the program; however, the annual banquet will be held.

Two early morning classes are planned for October 7 and 8. The annual meeting of members will be held October 6. The exhibit will be held and limited to the three days.

THE LOOK BOX

C.N.G.A. Forms War Activities Committee

With a number of its members serving on various government and war committees, the formation of a War Activities Committee, consisting of these men, as a move to coordinate the aid which the natural gasoline industry can give the war effort is announced by the California Natural Gasoline Association.

The committee consists of W. W. Robinson, The Texas Company, and a member of the California Oil Industry Salvage Committee, chairman; William Moeller, Southern California Gas Company, chairman of the Natural Gas and Natural Gasoline Committee, District 5; H. L. Eggleston, Gilmore Oil Company, chairman, Temporary Sub-Committee on Natural Gasoline and Coordination of Iso-Butane, District 5; P. S. Magruder, General Petroleum Corporation, member of the Oil Industry Protection Committee; and R. D. Gibbs, chairman of the C.N.G.A. Gas Report Committee. Ex-officio member of the committee is George L. Tyler, C.N.G.A. secretary.

Appointment of the committee is designed to bring together those members serving on special committees outside C.N.G.A. but whose functions have a bearing on the natural-gasoline industry who are working with special war-time questions and problems so that the full aid of the association and its various technical committees can most effectively be applied.

CONVENTIONS

SEPT. 7–11	American Chemical Society, Buffalo, New York.
16–18	National Petroleum Association, Traymore, Hotel, Atlantic City.
OCT. 5– 9	National Safety Congress and Exposition, Chicago.
12–14	American Society of Mechanical Engineers, Rochester, New York.
12–17	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Los Angeles.
25–29	National Lubricating Grease Institute, New Orleans.
29–31	American Institute of Mining and Metallurgical Engineers, Petroleum Division, Austin, Texas.
NOV. 6	California Natural Gasoline Association, Los Angeles.
9–13	American Petroleum Institute, Palmer House, Chicago.
16–18	American Institute of Chemical Engineers, Netherland Plaza Hotel, Cincinnati.
17–21	National Chemical Exposition and Industrial Conference, Chicago.
30	American Society of Chemical Engineers, New York.

API Meeting Moved To Palmer House

The annual meeting of the American Petroleum Institute, November 9 to 13, will be held in the Palmer House, Chicago, instead of the Stevens Hotel, as originally announced. The change was made following the recent conversion of the Stevens Hotel to military use.

"This will be strictly a war convention," was the interpretation put on the meeting by W. R. Boyd, Jr., president. "The Institute's annual meetings always have been working sessions. Now the far-reaching problems of the war make it more essential than ever to assemble the oil industry's workers periodically for an analysis of common difficulties."

Only those committees which are working on problems contributing in some measure to the war effort will convene during the meeting. Technical group sessions will deal largely with war-time progress in various branches of the industry. There will be no annual dinner.

Committees are now working on the program, whose scope was outlined by Boyd:

"The industry's technological problems are magnified a hundredfold by war—by lack of necessary materials, by disruptions of transportation, by demands for war products, and by shattering blows at the normal conduct of an integrated business such as ours, where the slightest alteration in supply and demand in one part of the country has its inevitable reaction in other parts of the country.

"Even more important than the discussion of these problems, perhaps, is the opportunity that wartime meetings afford to learn just what the government has been doing, and what it intends to do, that affects the oil business. We expect that the Petroleum Coordinator, the Deputy Coordinator, and divisional heads of that organization and authorities in other war agencies having to do with petroleum operations will attend and discuss in general sessions the problems in which every oil man is so vitally interested."

W. P. R. A. Planning Two Regional Meetings

Western Petroleum Refiners Association will have two regional technical meetings in October. The first will be held in the Allis Hotel, Wichita, October 9 and the second at Shreveport, Washington-Youree Hotel, October 30.

Subjects and speakers will be announced later. Each program will consist of three timely technical papers. Discussions likely will center around the effects of the war emergency on the refining industry.

Petroleum Division of ACS to Meet at Buffalo

Contrary to earlier decision, there will be a meeting of the Division of Petroleum Chemistry as part of the meeting of the American Chemical Society at Buffalo, September 7 to 11. Previously it had been announced that the other 17 divisions would have programs for this meeting but that pressure of the synthetic rubber program on petroleum chemists was such that this division would defer its meeting.

A part of the program for the Buffalo meeting will be a general meeting of public interest the afternoon of Sep-

tember 9. A series of papers will be presented.

Divisional programs will start September 7, continue the next day and be resumed September 11.

Illinois Mineral Meeting Cancelled

The Illinois Mineral Industries Conference, scheduled for Urbana, October 30 and 31, has been cancelled. Instead, the Illinois Mineral Industries Committee, the Engineering Experiment Station of the University of Illinois and the State Geological Survey, sponsors of the meeting, will take part in the regional conference of the American Institute of Mining and Metallurgical Engineers, St. Louis, October 1 and 2.

LPG Directors Reelect Officials

All officials of the Liquefied Petroleum Gas Association have been reelected. Directors of the association met in Washington for the purpose, as well as that of conferring with representatives of the Office of Petroleum Coordinator.

The officials are: George W. Bach, Skelgas Division, Skelly Oil Company, president; Ellsworth L. Mills, Bastian-Blessing Company, Chicago, and Ernest Fannin, Fanning Gas & Equipment Company, Phoenix, Arizona, vice presidents; Franklin R. Featherstone, secretary-treasurer.

Hovey Reelected by Gulf Coast Refiners

D. W. Hovey, vice president of Republic Oil Refining Company, Houston, has been reelected president of Gulf Coast Refiners Association. Other officials are George Irvine, American Republics Corporation, vice president; John A. Bartless, Amsco Corporation, Corpus Christi, second vice president; L. F. Rothermel, Maritime Oil Company, Houston, treasurer, and George W. H. Reid, Houston, executive secretary.

Bruce K. Brown Assistant To Deputy Coordinator

Bruce K. Brown, who has been a consultant in the Office of the Petroleum Coordinator for seven months, has been named an assistant to Ralph K. Davies, the deputy coordinator. He will devote most of his time to the fields of petroleum refining and marketing. As a consultant he was concerned chiefly with increasing the output of aviation gasoline.

Brown came to the staff of the Petroleum Coordinator from Standard Oil Company (Indiana). He joined that company in 1929 as a patent attorney. Later he was placed in charge of research and development and became a member of the board of directors. Prior to joining the oil company he had had experience as a research chemist and as a lawyer in the chemical field.

Johnston Heads NPA Safety Department

Hollis A. Johnston, Sinclair Refining Company, Wellsville, New York, has been named president of the department of fire and accident prevention of National Petroleum Association. He has been in charge of these activities at the Wellsville plant for 13 years.

Controversy Indicates Quicker Butadiene Yield

In the controversy and confusion of the synthetic rubber program last month there were indications of progress. Growing pains were evident in the approach to the making of butadiene, foremost petroleum ingredient for rubber requirements. Claims of rival processes were based on the contention that quicker and cheaper methods had been found rather than that former methods were impractical.

Foremost of the proposals was that of Eugene Houdry, who went on record to the effect that alterations in his catalytic process would provide butadiene by charging butane, thus eliminating the steps of dehydrogenation that attend the fluid catalyst process of Standard Oil Company (N. J.). Previously the lattter had advanced a change in technique whereby its units can be operated to produce butylene, which requires but one step in dehydrogenation.

Meanwhile the refining industry pressed its program for producing butadiene in quantity from existing equipment, pending completion of its plants designed for that purpose. Wright W. Gary, refining director of OPC, has completed a tour of refining centers in behalf of the program, which involves operating thermal-cracking units at higher temperatures, injection of superheated steam, recovery from flue gases, air injection into thermal-cracking process and especially designed furnaces, filled with brick. Details are not permissible but it is known that refining concerns are now estimating what part of existing equipment can be converted to one or more of these stop-gap methods of producing butadiene.

The approach is similar to that which came shortly after the industry embarked on its program of making 100-octane aviation gasoline. While the special plants were under construction it was learned that high yields of essential ingredients could be had by altering operating methods of existing equipment.

A tribute to the plan came from W. S. Farish, president of Standard Oil Company of New Jersey, who told a House Mines and Mining subcommittee June 15 that resort to existing equipment would permit that company to produce between 15,000 and 30,000 tons of additional butadiene in 1942. Interpreted in synthetic rubber, he added, it would provide an additional 200,000 tons of synthetic rubber during 1943.

"This is good news," he said, "but it does not warrant undue optimism on the part of the American motorist."

Hope for the motorist, however, came with a proposal of the rubber industry, which set up an exihibit in Washington, based on a combination of Thiokol, butyl rubber, rubber reclaim and a limited amount of crude rubber, which was offered as a means of producing useable tires, which will not withstand high speeeds and will not give long mileage.

The clash of processes came into the open when the Houdry Process Corporation used newspaper space to give its claims publicity. For several months there had been intimations that the petroleum industry was not of one mind on the question of the quickest and cheapest method of making butadiene. The Houdry Catalytic Process, long used for making gasoline and other distillates, was offered as capable of producing butadiene direct by charging butane to the catlytic unit.

Houdry, Clarence H. Thayer, chief engineer of Sun Oil Company; Arthur E. Pew, vice president of Sun Oil Company; W. S. Burt, Socony-Vacuum Oil Company, and J. L. Hanna, Standard Oil Company of California, appeared before the special synthetic rubber investigating committee of the House of Representatives.

Substance of their testimony was that the five companies which will operate the Neches Butane Products Company had sought to have the Houdry process substituted for the fluid catalyst process of Standard Oil Company of New Jersey, that Sun Oil Company had sought permission to build a Houdry unit for butadiene manufacture and that governmental agencies had refused to allocate materials or to change processes in plants already under construction.

In its newspaper advertising campaign Houdry Process Corporation stated that 15 standard-size units would produce enough buatdiene to provide 1,000,000 tons of synthetic rubber in a year. Steel requirements for the 15 plants was given as 180,000 tons, "from one third to one half less than required for the next best petroleum process." Construction time was given as 9 months per unit, provided materials are allocated and available. The time element was given as four months shorter than other processes.

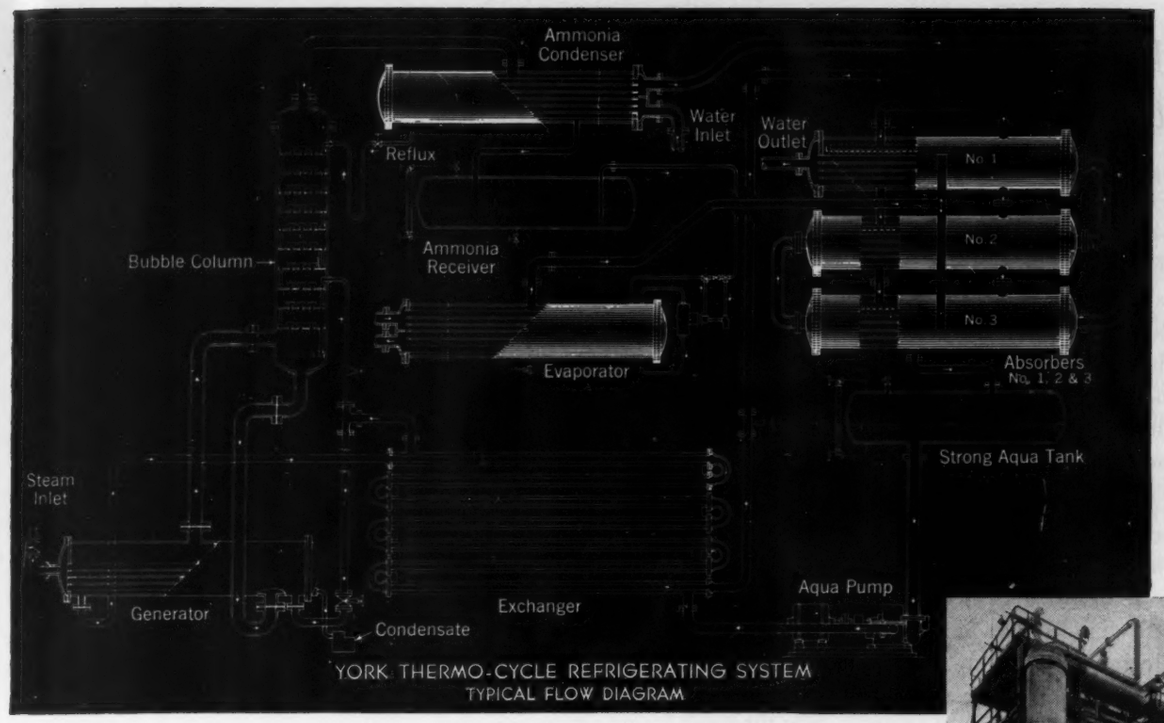
That the Houdry process was having consideration came from testimony before the House committtee, where testimony was to the effect that Standard Oil Company of California has recommended the process and that Phillips Petroleum Company, whose butadiene unit has been approved and some work done, also is giving attention to the Houdry method.

All in all the controversy added up to assurance that the synthetic rubber program will have its major requirement, butadiene, sooner than previous plans contemplated. Perhaps the best evidence of this was the production of this ingredient from conversion of existing equipment to butadiene manufacture. This trend was summed up by W. S. Farish in his testimony before the House Committee on Mines and Mining.

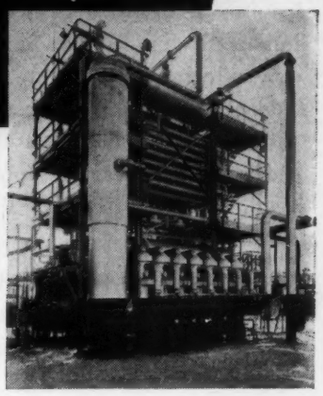
The 700,000-ton production of Buna S planned, Farish estimated, will require $81,900,000 worth of grain for production of 210,000 tons of butadiene and for a portion of the raw materials for styrene; $9,900,000 worth of benzol from the coal industry for most of the raw material for styrene and a small amount of butadiene, and $22,300,000 worth of refinery gases from the petroleum industry for 325,000 tons of butadiene and some of the raw materials for styrene.

On the whole, he declared, synthetic rubber will be better than natural after present "bugs" have been eliminated; Butyl tires today are good for at least 60 percent of the mileage of natural rubber, and Buna tires consistently give better service than natural rubber under normal road conditions.

Buna rubber initially will cost about 30 cents a pound when made from butadiene out of petroleum, but may be cut to 20 cents or less when the plants are running with maximum efficiency: Butyl will start with a cost of about



YORK THERMO-CYCLE REFRIGERATING SYSTEM
TYPICAL FLOW DIAGRAM



York Thermo-Cycle Refrigeration Systems

for Production of Synthetic Rubber and Processing of High Octane Gas

In the new super-efficient York Thermo-Cycle Refrigerating System, operation remains in the invisible hands of York engineers who design these units.

Even the largest installations (employing 1000 tons or more of refrigeration) are operated entirely by automatic controls which coordinate all functions of the system more smoothly than would be possible with manual control. Coupled with this smoothness of operation is a *flexibility* that insures efficient operation on any percentage of load.

Simplified design, in which the ammonia pump is the only moving part, means fewer joints and parts, less maintenance, reduced overhead and a plant ideally adapted to continuous operation. The system may be operated on exhaust steam or may be direct gas-fired.

Important in these days of material shortage and restriction is the fact that no buildings are required and only the erecting time for the machinery itself need be figured in planning production. York Ice Machinery Corporation, York, Pennsylvania.

YORK REFRIGERATION AND AIR CONDITIONING

"Headquarters for Mechanical Cooling Since 1885"

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Structural Members Do Double Duty on this Efficient Pump

The design of this Amsco-Nagle Pump conserves vital metal, saves unnecessary weight and makes possible its high efficiency. The two structural supports that secure the water end to floor plate also serve another purpose. The strut on the left acts as a lubrication duct conveying lubricant from above the floor plate to the submerged bearing. The strut on the right serves as the discharge pipe.

This pump, a 2″, Type "SW", frame 7 unit, has another distinctive design feature—an inverted inlet. This arrangement eliminates gas-binding and causes hydraulic thrust to counterbalance the weight of the revolving parts. The steady bearing at the water end is a sleeve bearing supported in a split yoke and is replaceable without dismantling.

Steam Turbine Propelled Pump

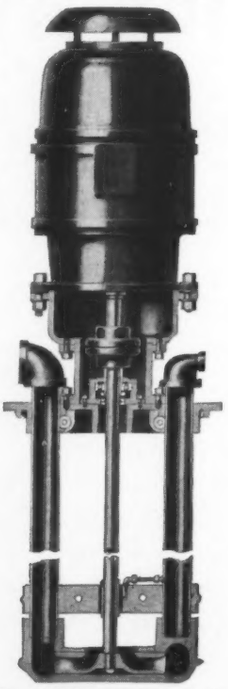
Ordinarily Amsco-Nagle Vertical and Horizontal Shaft Pumps are supplied as shown in the sectional drawing with a standard electric motor of characteristics as specified by purchasers of the pump; but, on the pump pictured (below, left), a Wing Mfg. Co. steam turbine power unit is used.

This pump was built to handle residue from a coke oven by-products chemical still, similar to the residue from petroleum stills.

While water ends can be made of impact and abrasion resistant manganese steel, Amsco Alloy, monel, bronze, and a variety of other metals, depending upon the corrosive or abrasive nature of the material handled, the water end of this particular pump is of ordinary cast iron which was most economical in this case.

War times call for maximum economy and efficiency in all operations and processes and as far as concerns pumping heavily loaded liquids or liquids carrying abrasive material in suspension, Amsco-Nagle Pumps meet the requirements. Available from ¾″ to 12″; capacities to 7,000 g. p. m. for heads up to 200 ft. Bulletin 940 gives complete details.

Steam Turbine Propelled Pump



Type "SW" Amsco-Nagle Pump

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Manganese Steel Castings for shocks and abrasion.
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20 cents a pound and may eventually get down to somewhere between 10 and 15 cents.

Cost of constructing plants has been reduced materially, Farish said. Butyl plants originally estimated to cost as high as $750 per ton are now expected to cost about $350 a ton of annual capacity; Buna plants, originally estimated to cost $1000 a ton now are figured at about $600.

Civilian Rubber

The government rubber program will probably take care of military needs, Farish said, but the great element of doubt is what is going to occur to essential civilian transportation.

"In the oil industry we came to the conclusion a few months ago that a solution had to be, and could be, found, and that the way to do it was by 'makeshift plants'—using spare equipment we had and odds and ends of junk to patch up temporary facilities which would turn out rubber and rubber raw materials," he explained.

"In the case of Buna rubber, which is the basic type, the bottleneck was butadiene production. If more butadiene could be produced quickly, the entire program could be speeded up by several months.

"There will be some expense in throwing this makeshift equipment together, and operations will be inefficient and the butadiene will cost more than when made in properly designed new plants," he admitted. "But the important thing," he insisted, "is that the oil industry is actually going to be able to produce some real amount of butadiene by these methods well in advance of the regular program, and since butadiene is the bottleneck that means just so much additional rubber."

A similar approach has been worked out for Butyl rubber, and a practical solution of the problem is anticipated before the end of the year. This work will involve the expedient of using dry ice as a refrigerant. The product is called Flexon which, he admitted "is still sometimes pretty bad" but which, he claimed, will be better than reclaimed rubber for tires and will be improved.

That the War Production Board is fixed on a policy of sticking with plants and processes as previously approved but of open mind as to other methods as they are developed was the substance of testimony by Donald M. Nelson before a subcommittee of the Senate Committee on Agriculture May 14. In this he opposed creation of an additional agency of government to handle synthetic rubbber. After giving details of plant progress and an estimate of plant output, he spoke of processes as folllows:

"That decision of the board to proceed under present plans with all possible speed, does not exclude encouragement of any assistance to continued technological developments still ahead in the entire field of synthetic rubber. I am particularly interested in and I have given all the encouragement I can to the development of the butyleneglycol process now under test by the Northern Research Laboratories at Peoria, Illinois. I have followed very closely and have been in touch with the parties interested in the development of the so-called Polish process, which is being sponsored by the Publiker Corporation. The Publiker Corportaion was granted an A-1-b priority rating on

March 31, which was moved up to an A-1-a rating on June 27 for materials necessary to build a 2000-pound-per-day pilot plant for the continued testing and development of that process.

"Other instances of prospective favorable technological developments have been brought to my attention and are being assisted. Rubber requirements are under continual careful review in relation to the available supply of scarce materials for construction. If it should later be determined that the present program much be expanded to meet requirements, then ensuing technological developments will be most carefully weighed and will share a part in the program if shown to be merited."

Synthetic Rubber Plants

Since the status of synthetic-rubber-plant construction (tabulated below) was compiled in Washington the Butyl rubber total has been increased to 130,000 tons, which will be accomplished by improvements in plant operation and will not require additional critical materials.

Not included in this tabulation is the "quick butadiene program," whereby additional amounts are to be made in existing equipment with the result that the output will be higher than anticipated during the next 18 months. W. S. Farish, president of Standard Oil Company (New Jersey) told the House Committee on Mines and Mining that his company expected to produce from 15,000 to 30,000 tons more than previously anticipated during that period. He outlined its prospects as follows:

"Remember this is entirely outside of the government's program and does not involve building new plants. There will, of course, be some expense in throwing together this makeshift equipment. The operations will be inefficient and the butadiene will cost more than when made in properly designed new plants. But the important thing is that the oil industry is actually going to be able to produce some real amount of butadiene by these methods well in advance of the regular program. If these emergency or makeshift programs give us only 50,000 tons of additional rubber before the end of next year that means an additional 8,500,000 tires. There is indication that we ought to get more than this. I should like to see at least 200,000 tons more from these makeshift programs and I think it is possible."

The cost of plants has been substantially reduced since first estimates were made. For Buna rubber the per-ton cost is down from $1000 to $600. For Butyl rubber the original cost of $700 per ton has been cut in half.

The tabulation of plant ownership shows how the synthetic rubber program has been divided. Butadiene and styrene will be made in plants operated for agencies of government by the petroleum industry. Compounding of these products with other chemicals to finish the rubber and make it into finished products will be done in plants operated by the rubber industry. Only Butyl rubber will be completed by the petroleum industry while neoprene will be made in plants operated by E. I. du Pont de Nemours & Company.

Nelson Clarifies the Rubber Controversy

While testifying before the subcommittee of the Senate Committee on Agriculture, July 14, Donald M. Nelson gave information that sets forth the reasons for turning to petroleum as a source for synthetic rubber as well as

Synthetic Rubber Plants Under Contract

Plants to Manufacture Synthetic Rubber Ingredients

NAME	Production Capacity in Short Tons per Year		Completion Date
Butadiene Plants:			
Shell Chemical Co.	30,000		March, 1943
Southern California Gas Co.	25,000		January, 1943
Humble Oil & Refining Co.	30,000		March, 1943
Standard Oil Co. of La.	6,200		September, 1942
	15,000		March, 1943
Carbide & Carbon Chemical Co.	5,000		September, 1942
	20,000		January, 1943
	20,000		February, 1943
	20,000		March, 1943
	20,000		April, 1943
	20,000		April, 1943
	20,000		May, 1943
	20,000		June, 1943
	20,000		May, 1943
	20,000		June, 1943
	20,000		July, 1943
Atlas Oil & Refining Corp.	12,000		November, 1942
Neches Butane Products Co.	50,000		April, 1943
	50,000		June, 1943
Rubber Synthetics, Inc.	50,000		June, 1943
	50,000		August, 1943
Koppers United Co.	20,000		August, 1943
Sinclair Rubber, Inc.	50,000		October, 1943
Cities Service Refining Co.	55,000		August, 1943
Total Butadiene		648,200	
Styrene Plants:			
Dow Chemical Co.	25,000		March, 1943
Monsanto Chemical Co.	10,000		October, 1942
	10,000		January, 1943
	5,000		February, 1943
	5,000		March, 1943
Carbide & Carbon Chemical Co.	12,500		January, 1943
	12,500		April, 1943
Dow Chemical Co.	4,200		January, 1943
	25,000		April, 1943
	25,000		June, 1943
	12,500		August, 1943
Koppers United Co.	35,000		August, 1943
Total Styrene		181,700	
Total Ingredients		829,900	

Plants to Manufacture Finished Synthetic Rubber

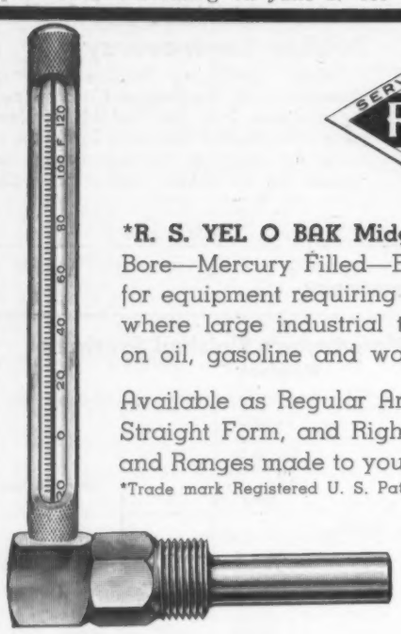
NAME	Production Capacity in Long Tons per Year		Completion Date
Copolymer Synthetic Rubber Plants:			
Firestone Tire & Rubber Co.	30,000		February, 1943
	15,000		June, 1942
	15,000		September, 1942
	15,000		June, 1943
	15,000		July, 1943
	15,000		August, 1943
	15,000		August, 1943
Goodyear Tire & Rubber Co.	15,000		May, 1942
	15,000		August, 1942
	30,000		June, 1943
	30,000		April, 1943
	15,000		May, 1943
	10,000		June, 1943
	55,000		October, 1943
The B. F. Goodrich Co.	30,000		November, 1942
	30,000		January, 1943
	30,000		April, 1943
	15,000		May, 1943
	10,000		June, 1943
U. S. Rubber Co.	30,000		January, 1943
	30,000		March, 1943
	30,000		May, 1943
	15,000		August, 1942
	15,000		November, 1942
	15,000		June, 1943
	15,000		July, 1943
	15,000		August, 1943
To be determined	30,000		June, 1943
	30,000		June, 1943
	15,000		August, 1943
Total Copolymer Rubber		645,000	
Butyl Synthetic Rubber Plants:			
Standard Oil Co. of La.	7,000		November, 1942
	33,000		July, 1943
Humble Oil & Refining Co.	20,000		July, 1943
Total Butyl Rubber		60,000	
Neoprene Synthetic Rubber Plants:			
E. I. Dupont De Nemours & Co.	10,000		October, 1942
	10,000		April, 1943
	20,000		October, 1943
Total Neoprene Rubber		40,000	
Total Synthetic Rubber		745,000	

the possibility of adapting other materials as technological information is made available. On this subject he said:

"That decision of WPB to proceed under present plans with all possible speed does not exclude encouragement of any assistance to continue technological developments still ahead in the entire field of synthetic rubber. I am particularly interested in and I have given all the encouragement I can to the development of the butylene-glycol process now under test by the Northern Research laboratories at Peoria, Illinois. I have followed very closely and have been in touch with the parties interested in the development of the so-called Polish process which is being sponsored by Publiker Corporation. The Publiker Corporation was granted an A-i-b priority rating March 31, which was moved up to an A-1-a rating on June 27 for materials necessary to build a 2000-pound-per-day pilot plant for the continued testing and development of that process.

"Other instances of prospective favorable technological developments have been brought to my attention and are being assisted. Rubber requirements are under continual careful review in relation to the available supply of scarce materials for construction. If it should later be determined that the present porgram must be expanded to meet requirements, then ensuing technological developments will be most carefully weighed and will share a part in the program if shown to be merited."

He gave a tabulation of prospective output of synthetic rubber from the plant construction program now under way and expressed the view that the goal will be met.



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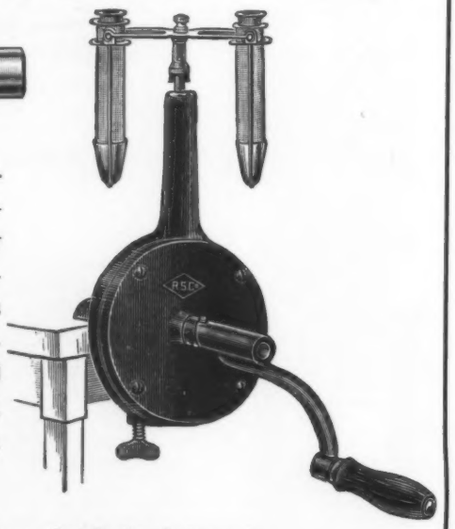

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Butyl Rubber Increase Approved by WPB

Production of an additional 70,000 tons of Butyl rubber per year without expenditure for critical construction materials has been approved by War Production Board. Advanced engineering will permit production of this additional amount in equipment previously credited with 60,000 tons per year. The increase raises the total synthetic rubber program to 870,000 tons annually. Its influence on the whole program was outlined as follows:

"The expanded program is not expected to alter the projected figure of 300 tons of Butyl rubber to be produced in 1942. The increase does not change the current picture, and the facts on the rubber situation indicate, as has been said before, that there is no rubber to spare for non-essential purposes.

"Butyl rubber has been found to be extremely useful in the manufacture of gas masks, anti-gas clothing, raincoats, rubber boats, life preservers, barrage balloons, wire insulation, and miscellaneous moulded goods. It is also being experimented with for use in tires, although indications are it is not equal to Buna S synthetic rubber for tire purposes."

No Opposition to Alcohol Program

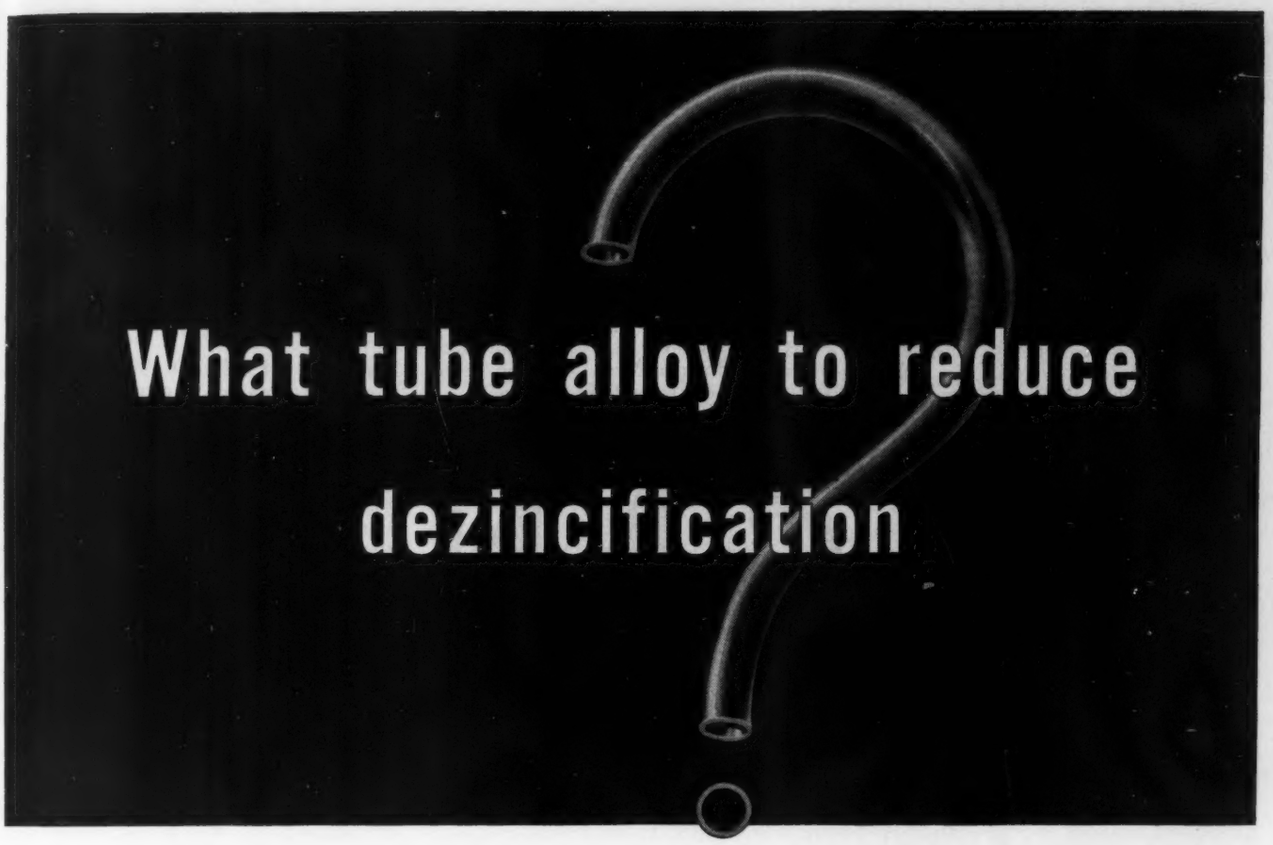
Statements that executives of the oil industry are deliberately striving to prevent manufacture of butadiene from farm products have drawn denials from three sources. Each makes a point of the fact, well known, that the petroleum industry is vitally concerned about tires, since they are the key to gasoline consumption, which in trun determines the profit to any unit in the petroleum industry.

This statement was given out by E. G. Seubert, president of Standard Oil Company (Indiana):

"We do a great deal of business with farmers. We should like to see them having a hand in supplying the raw materials for rubber. More rubber will make it more possible that civilian automobiles can be kept running. And the more they can be kept running the better business will be for the oil companies. It just does not make sense that the oil companies should oppose any kind of manufacture of rubber. Whatever the difficulties about manufacture of rubber from alcohol may be, monopolistic designs by oil companies are not among them."

How little of the total production of crude oil will get into synthetic rubber was brought out by John A. Brown, president of Socony-Vacuum Oil Company:

"The paramount interest of the petroleum industry is to have as much synthetic rubber as possible made available to the public. The petroleum industry's very existence is primarily dependent on a large consumption of gasoline, which in turn is dependent on an adequate supply of rubber. Where that rubber originates — whether from oil or from alcohol from grain, is of little commercial interest to the oil industry. Our primary interest is that there shall be an adequate supply of rubber. Except in isolated cases, the policy has beeen for the government to build and own the plants and for the oil companies to operate them without profit. The



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OVER ten years ago our research indicated that a small percentage of arsenic in the standard Admiralty Alloy would materially increase its resistance to dezincification.

We produced tubes of this modified Admiralty Alloy in 1934. Since then, installations in practically every type of service have proved consistently satisfactory.

While Anaconda Arsenical Admiralty Condenser Tubes have been quite generally used, they are especially well-adapted to those installations in which the older alloys showed definite tendencies to dezincify.

TECHNICAL SERVICE AVAILABLE

It is a function of the engineers of our Technical Department to assist Condenser Tube users in the selection of the most economical tube alloy for any given set of operating conditions. Please feel free to call on us. Publication B-2, sixth edition, gives up-to-the-minute data on Anaconda Condenser Tube and Head Plate Alloys. A copy will be mailed to you for the asking

428

ANACONDA
from mine to consumer

Anaconda Condenser Tubes

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purpose of these plants is not to make rubber but to make butadiene, one of the principal ingredients in synthetic rubber. Seven hundred thousand tons has been mentioned as the necessary output of synthetic rubber for 1944. Seven hundred thousand tons of synthetic rubber would require less than one percent of the oil industry's daily petroleum volume."

In the July issue of **The Lamp** this position was outlined by Standard Oil Company (N. J.):

"Standard Oil Company (N. J.) supports and will fight for just one program for the production of synthetic rubber. That is, whatever program the government adopts to give our nation the most rubber in the shortest time, from any raw materials whatsoever and with the least possible drain on vital construction materials.

"So critical is the rubber situation that any action which confuses or diverts government or industry from speedy completion of the main program harms our national security. This company has given the government all the information it possesses on the manufacture of synthetic rubber by any process. Since petroleum is our basic raw material and a natural, abundant American resource, Jersey naturally is experienced only in the production of synthetic rubber from petroleum. Our researchers did show us in 1935 that alcohol could be turned into synthetic rubber but the production economics of that day did not favor this route. Today the cost figure must be of minor consideration.

"The main business of an oil company is to sell gasoline and lubricants. These can not be sold to cars which are laid up for lack of rubber. Actually $15 to $20 worth of products and services are sold by oil companies and their dealers for every $1 worth of tires. The value of the petroleum raw materials in $1 worth of synthetic rubber is 10 cents. Any selfish interest which might be attributed to the petroleum industry would be in selling gasoline and oil and not in the direction of obtaining a big share of synthetic rubber production."

Bureau of Mines Will Produce More Helium

Under a new program of the Bureau of Mines, helium gas will be produced in greatly enlarged quantities from the bureau's expanded helium plant in Texas in order to meet war requirements. Also, a new helium production plant at an undisclosed location will be supplied with helium-bearing natural gas from an existing pipe line transporting gas for fuel purposes.

An appropriation of $4,000,000 to become available from Navy Department funds will enable the bureau to carry out expansion of its helium-production program. Engineers and geologists of the bureau are studying gas fields for the purpose of establishing new helium reserves.

In 1920 the bureau built the present plant near Amarillo, where a gas field of 50,000 acres was taken under government control. During 12 years this field produced over 100,000,000 cubic feet of helium, but until the last year the bureau did not operate the plant at full capacity.

Procedure in Case Of Higher Priority

New procedure for obtaining higher priority ratings for materials required to complete projects already under way has been explained by Deputy Petroleum Coordinator for War Ralph K. Davies.

Previously, when a contractor could not complete his construction work because certain materials had not been delivered, and delivery was being held up because the original priority rating no longer was high enough, the contractor applied for a higher rating on Form PD-1A.

Now, application for higher priority rating need not be made on Form PD-1A. Correct procedure is to write a letter in quadruplicate in which is listed all material items requiring a change in preference rating status. Thus, requests for changes in ratings can now be made in one application, whereas previously a separate PD-1A form had to be made out for each class of items.

In compiling the list of materials in the single application, under the new procedure, however, applicants are requested to itemize the materials in accordance with the PD-200A materials list.

The letter should also include information showing builder's serial number, item number, unit of measure, quantity, price, and use of item; latest delivery date permissible, and preference rating required by the supplier to meet the delivery date.

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¾ inch thickness, 10 ft. diameter by 40 ft. long

See COMPOSITE CATALOG Refinery Equipment, Pages 543 to 544.

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These successful tests, coupled with Gloweld's comparatively lower cost, forecast wider applications for stainless steel tubing.

Gloweld is a development of Globe Steel Tubes Co., pioneer manufacturer of stainless steel tubing. It is produced by a closely controlled electric welding process resulting in very little "flash" at the weld, which is removed in a subsequent operation.

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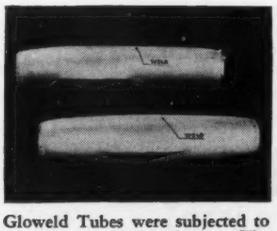
Milwaukee, Wisconsin

Standard laboratory tests, with boiling 65% Nitric Acid, with Nitric and Sulphuric Acids, and by exposure to salt spray, and the Strauss Test, have established the corrosion resistance of Gloweld.



Gloweld Tubes were subjected to pressure until they burst. The weld in every case was as strong as the strip steel.

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GLOBE STEEL *Tubes*

Bureau to Study Coal As Gasoline Source

Detailed study of coal as a source of gasoline and lubricants will be undertaken by the United States Bureau of Mines. The work will be done at the Pittsburgh station with funds appropriated.

The Fischer-Tropsch method—one of the two direct processes for the production of motor fuels from coal—will be investigated with a view to developing means to produce gasoline from the coals of Alaska and the United States, Dr. R. R. Sayers, director, advised Secretary of the Interior Harold L. Ickes. The other methods—a modification of the Bergius hydrogenation process—has been studied by bureau chemists for several years.

This projected research will comprise another Bureau of Mines contribution to the nation's wartime program for exploring and developing all possible sources of synthetic motor fuel for current emergencies and against the time when natural petroleum reservoirs may be depleted. The estimated life of petroleum reserves in the United States is said to be 15 years, Dr. Sayers stated, and we have already had a foretaste of what a shortage of motor fuels and lubricants can mean to this country.

"It is essential that steps be taken to provide for future needs and perhaps for immediate needs, such as supplying gasoline to air bases in Alaska and other remote outposts. The new appropriation of approximately $85,000 will enable the Bureau of Mines to establish a nucleus of men trained in the intricacies of the process who could assist or direct its industrial application wherever needed."

Following Congressional approval of the project and the allotment of funds in the 1943 Interior Department appropriation bill, plans were made for construction of the experimental plant adjacent to the Bureau's Central Experiment Station at Pittsburgh, Pennsylvania. It is proposed by the Bureau to staff the plant with competent chemical engineers and proceed immediately with the business of developing the Fischer-Tropsch process.

The experimental plant will have a capacity of about 100 pounds of gasoline per day and it will include chemical engineeering equipment such as catalyst chambers, pumps, charcoal scrubbers, distillation columns, cracking units, and the necessary instruments for control. Future plans call for a pilot plant to handle about 10 tons a day, and also a small plant which can be moved and erected in a short time and at little cost.

The decision to study the Fischer-Tropsch process to produce motor fuels from water gas in the Bureau's program was influenced to a degree by the fact that this process is reported operating on an industrial scale in Europe, especially in Germany, Dr. Sayers said.

Developed since 1926 by Dr. F. Fischer in Germany, the raw material of the Fischer-Tropsch process is a mixture of hydrogen and carbon monoxide gases produced from coal or coke and steam. After removal of sulphur compounds, this mixture is passed over a solid catalyst and the resultant products are propane, butane, gasoline, diesel fuel, and paraffin wax. About four or five tons of coal will yield a ton of products under present limitations.

The hydrogenation process studied by the Bureau of Mines in recent years consists of liquefying powdered coal in a high-pressure vessel with the aid of a catalyst and hydrogen gas. After liquefaction, the product is separated into gasoline, middle oil, and heavy oil by methods similar to those used in refining petroleum. About five tons of coal are required to produce one ton of liquid fuel.

The advantages of the Fischer-Tropsch method for current purposes—to provide economical and easily-built units for United States military outposts such as Alaska—are self-evident, Dr. Sayers stated. The smallest economical unit of the hydrogenation method is about 150,000 tons a year capacity, while a Fischer-Tropsch plant of 30,000 tons a year capacity may be operated economically. A smaller amount of precision machinery is required in the Fischer-Tropsch process and almost any type of coal can be used successfully. Certain coals, because of high ash content or sensitivity to temperature variations, offer serious operating difficulties in the hydrogen method.

An important consideration with regard to building processing plants in remote military posts is that the smaller Fischer-Tropsch units would offer less of a target for bombers and saboteurs if such enemy activity was imminent, Dr. Sayers pointed out.

In connection with the experimental plant at Pitttsburgh, the Bureau of Mines also received some funds for testing the various types of coals for adaptation in the water-gas process. This work will be pursued by technicians in the Bureau's existing fuel-testing sec-

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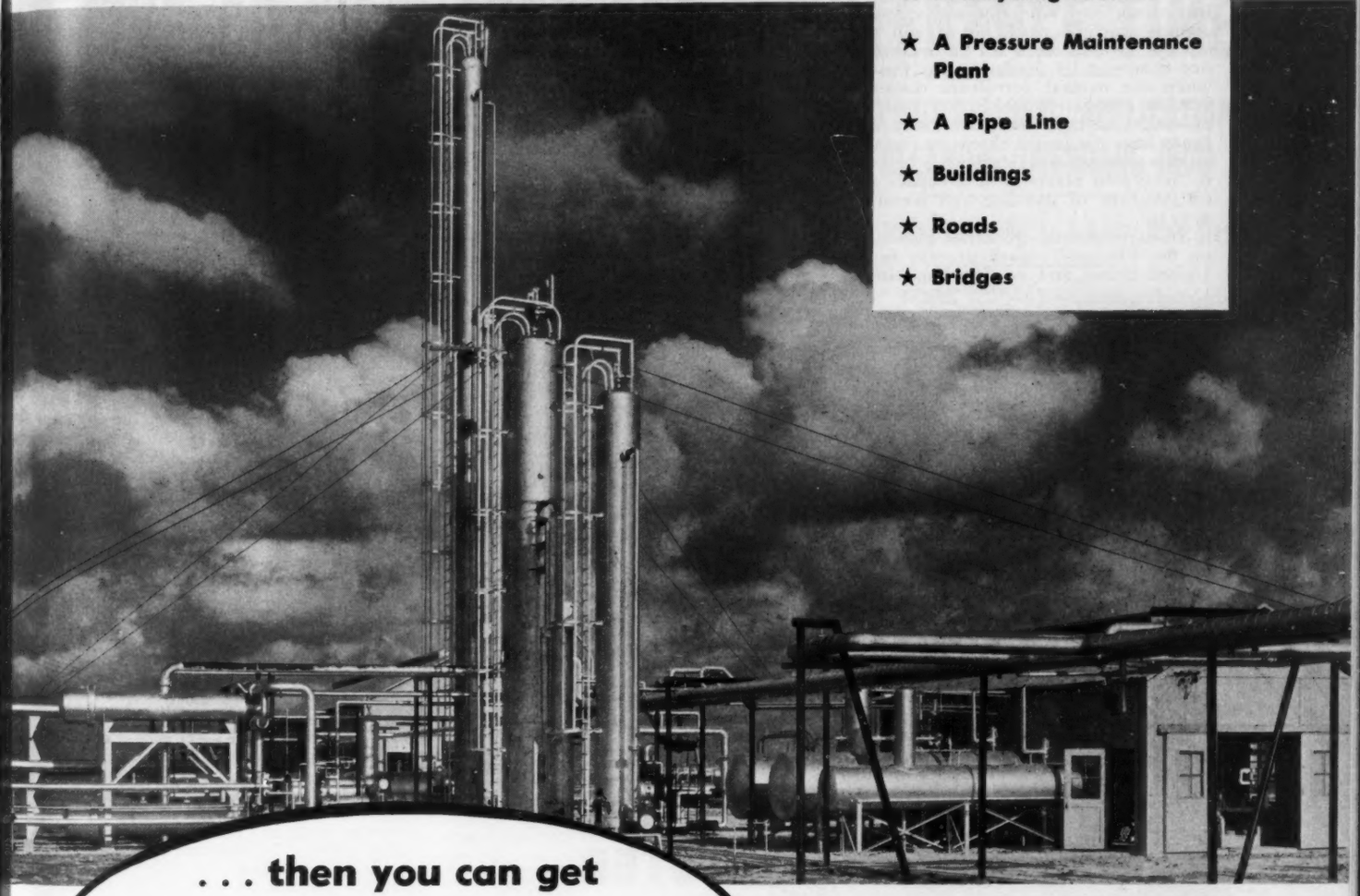

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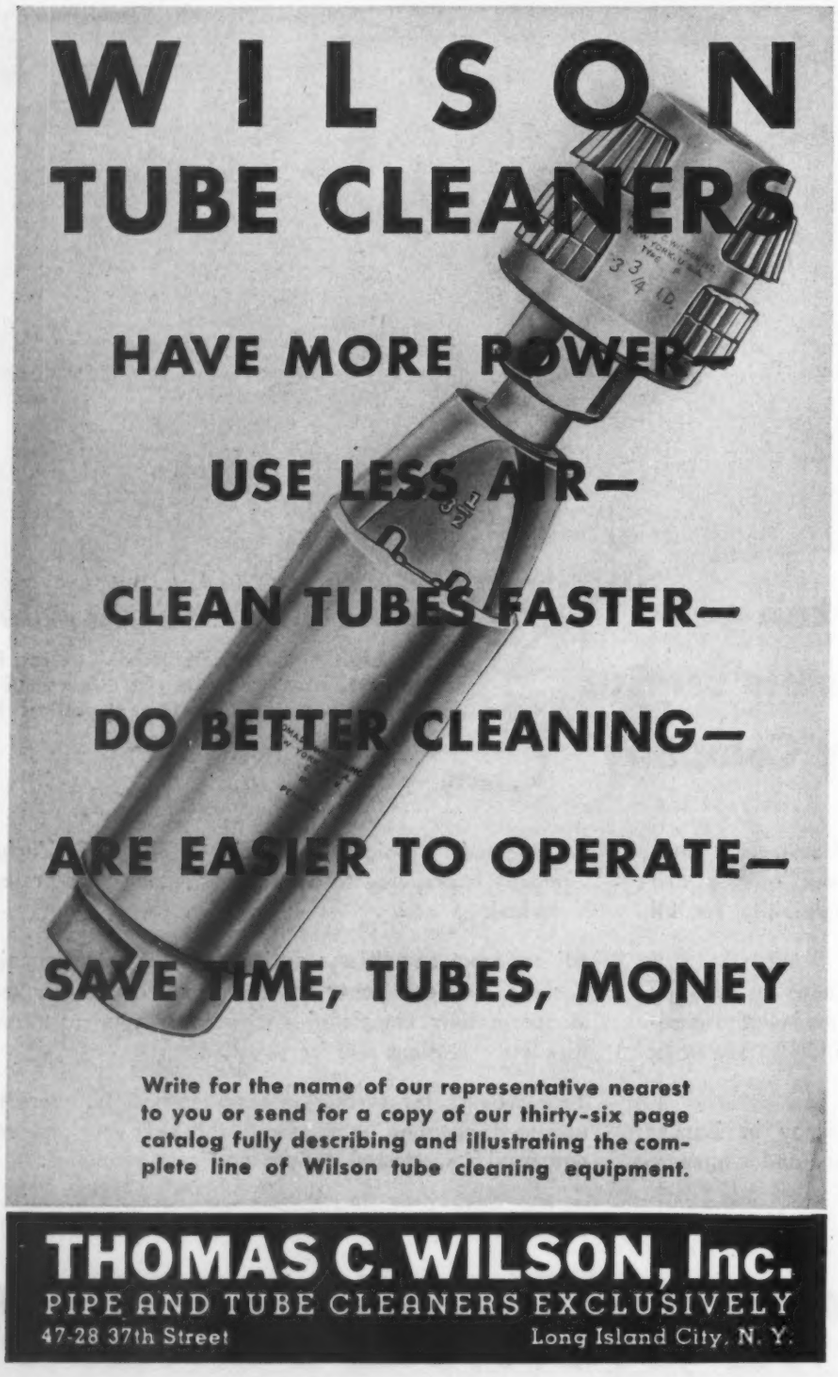
tion which for a number of years has beeen investigating the fuel potentialities of coal from the coal-producing states and Alaska.

Research in the production of motor fuels from coal not only will supply a definite wartime need, but it will also lay the ground work for future peacetice economy by preparing for the era when our natural petroleum resources may be exhausted, Dr. Sayers said. He pointed out that both Germany and Japan have conducted extensive research on this process, and Germany is believed to have nine plants with a capacity of 650,000 tons of gasoline and diesel oil a year.

No experimental work has been done on the Fischer-Tropsch process in the United States and no first-hand information is available on it, Dr. Sayers stated, adding that "the necessity for such work has assumed increased importance since the nation is at war."

Midgley to National Academy of Science

Thomas Midgley, Jr., who directed the research of General Motors Research Corporation in determining the application of tetra ethyl lead as an anti-knock agent for gasoline, has been elected an honorary member of the National Academy of Science. He is chairman of the board of the American Chemical Society and a vice president of Ethyl Corporation.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Gasoline Stocks Being Rapidly Depleted

Heavy gasoline stocks which menaced the market only a few months ago are rapidly being dissipated as the industry moves to meet the new conditions created by the war demand for special products and automobile and gasoline rationing, it is disclosed by the Bureau of Mines in its forecast of August crude oil demand.

With no necessity for the normal winter accumulation in anticipation of summer demand, it is unlikely that any effort will be made to conserve stocks, which the bureau foresees may be reduced to as little as 70,000,000 barrels by the end of September.

A daily production of 3,729,000 barrels—93,500 barrels more than the estimate for July but 342,600 barrels, or 8 percent, under actual demand in August, 1941—is forecast by the bureau as necessary to meet market demand for domestic crude this month.

The estimate for crude compares with a recommendation by Coordinator Ickes for a daily output of 4,308,500 barrels of petroleum liquids, which was an increase of 195,700 barrels over the July recommendation.

The bureau found that daily production during the five weeks ended July 4 was 3,608,000 barrels and total runs to stills 3,499,000 barrels, while stocks declined at a rate of 59,000 barrels a day, indicating a demand for domestic crude of 3,667,000 barrels.

"Total gasoline demand for the second quarter of 1942 was about 9 percent below the demand in the same period of last year and, according to the bureau's forecasts, may show a decline of about 17 percent in the third quarter, compared to last year," it was commented in a discussion of current trends.

"With the elimination of most of the summer peak in motor fuel demand, the usual pattern of gasoline stocks will be completely altered. With prospects for further reductions in gasoline demand next year, there will be no necessity for a large winter accumulation of stocks. Stocks of finished and unfinished gasoline are being reduced to meet this situation. A decline of about 19,000,000 barrels occurred in the second quarter of 1942, and a further reduction of about 15,000,000 barrels is anticipated in the third quarter. In view of present trends, total stocks of finished and unfinished gasoline may be reduced to between 70,000,000 and 75,000,000 barrels by September 30.

"The progress of these readjustments has reduced runs to stills and decreased the demand for crude petroleum, and has caused a shift in refinery yields as indicated by the May, 1942, figures, showing a gasoline yield of 39.9 percent and a residual fuel oil yield of 29 percent. The daily average demand for domestic crude oil was 3,766,000 barrels during the first quarter of 1942 and declined to about 3,658,000 barrels during the second quarter. While current demand for crude is at a somewhat higher level, any further substantial increase will depend upon the improvement of transportation facilities to the East Coast, on the scope of gasoline rationing necessary to conserve rubber, and on further readjustments to supply residual fuel oil.

"Under current transportation conditions a further substantial liquidation of crude oil stocks of Oklahoma and

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NEW YORK (CP) — Refineries throughout the country are utilizing CP Pneumatic Wrenches in all maintenance departments, wherever bolted equipment requires disassembling for overhauling and the reduction of "down time" is vitally important.

Five wrench sizes which cover all requirements in running nuts off and on pressure vessels, heat exchangers, coolers, condensers, and similar equipment, are responsible for the popularity of the CP line of impact type wrenches. Nuts, bolts, studs, lag screws, etc., from ⅜" up to 1¾" bolt size are speedily handled by these five sizes. Special features which appeal to refiners are listed in the "box" below. Write for further data.

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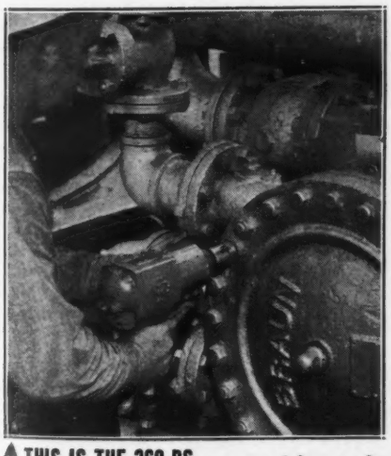

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Fewest Parts — Lowest Maintenance
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DRILLS
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FLUE ROLLERS
RIVETERS
GRINDERS
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Illinois origin is anticipated to supply part of the estimated total demand for crude petroleum in August."

Total demand for motor fuel for the month was placed by the bureau at 53,800,000 barrels, 18 percent under actual demand a year ago.

Stocks of finished and unfinished gasoline, which amounted to 94,681,000 barrels May 31, are indicated by the American Petroleum Institute as having declined about 7,200,000 barrels during June and the bureau estimates a further withdrawal of 5,500,000 barrels this month.

Direct sales of natural gasoline were estimated at 1,400,000 barrels, making an indicated refinery production of 46,900,000 barrels, which was allocated among the several districts as follows: East Coast, Inland Texas, Texas Gulf Coast, Louisiana Gulf Coast and Inland Louisiana-Arkansas, 19,800,000 barrels; Appalachian, 2,100,000 barrels; Indiana, Illinois, Kentucky, etc., 10,900,000 barrels; Oklahoma, 2,610,000 barrels; Kansas, 2,890,000 barrels; Rocky Mountain, 1,400,000 barrels; California, 7,200,000 barrels.

The bureau figured 3,980,000 barrels of natural gasoline to be blended at refineries, and a yield of gasoline from crude of 39 percent which, applied to the straight-run and cracked production of 42,920,000 barrels, gives total crude runs of 110,050,000 barrels, or 3,550,000 barrels daily. Crude for export and to be used as fuel, and losses, was estimated at 6,600,000 barrels, and the demand for domestic crude was placed at 115,600,000 barrels, or 3,729,000 barrels daily.

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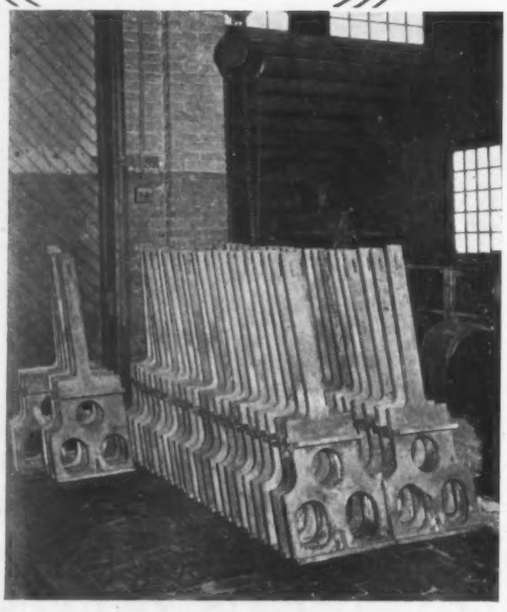
TUBE Supports almost invariably form a substantial part of our back log of orders. It's sort of a continuing business because many refiners long ago learned that DURALOY Tube Supports are *sound* and give maximum service. Requisitions specify "DURALOY."

In spite of a large business being done for war plants, we are still in position to make tube supports for you.



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8-DU-3

East Further Warned Of Acute Oil Shortage

The first week of hard-boiled rationing in the East brought little change in road conditions, but officials believed that much of the driving now is being done by motorists desiring to make the most of the summer weather and who later will lay their cars up or restrict their driving.

The first few days of the new rationing system, however, saw a change in conditions, with holders of coupons able to get gasoline at all service stations without difficulty, in contrast with the situation under the original combination of rationing and delivery-curtailment, when many stations were out of gasoline most of the time.

Developments during the week included a plea by President Roosevelt that owners of oil-heating equipment convert to coal wherever possible, backed up by Coordinator Ickes in a message to all East Coast oil sellers in which he pointed out that "we do not face a shortage, the shortage is here"; a decision of the Office of Price Administration to make no concessions for traveling salesmen and a report by an unofficial House committee urging extension of rationing to the Middle West so that more oil from that area might be diverted to the East.

Meanwhile plans were perfected for the extension of rationing August 22 to seven western New York counties heretofore excluded from the rationed area, where motor-car and truck owners will begin to register for the same type of coupon books next Monday.

In a note to Ickes, President Roosevelt said, "I earnestly hope that every citizen will realize the serious uncertainties which cloud our prospects for petroleum supplies on the Atlantic seaboard next winter. Whatever action he may decide to take, every user of fuel and heating oil should face realistically the fact that there can be no guarantee that he will get enough oil to meet even his minimum needs."

Passing the President's message along to the sellers, the coordinator stressed that the deficit in supply is so great that if every "truck, bus, taxicab and passenger car" in the Atlantic States were taken off the highways for the first two months of next year, the available transportation facilities still could not meet normal fuel and heating oil requirements.

There may be days next winter, he warned, when oil sellers as well as their customers will be completely without fuel and heating oils.

Declaring that presently-authorized rations, which will permit them 448 gallons of gasoline a year, are all that can be spared, Joel Dean, chief of the OPA fuel rationing division, explained that to give traveling salesmen the gasoline necessary to permit them to drive the average of 15,000 a year which the American Automobile Association estimated was covered by each of the 500,000 salesmen in the East would require 500,000,000 gallons of motor fuel.

The reduction of 55 percent which salesmen will be required to make in their travel, he said, will represent a saving of 1300 tank carloads of gasoline a day or, translated into fuel oil, enough oil to heat one eighth of all the home oil-heating plants in the area.

"Every possible step has been taken

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to assure fair consideration for salesmen because we realize their important contribution in pioneering new goods and new markets," Dean said. "Yet we had to weigh against our admiration for American salesmen the serious petroleum shortage we are facing today.

"There isn't enough gasoline for business as usual if we are going to take care of war workers and provide for heating homes."

Following a week of quick hearings, the special House committee of New England members held that "there is a dispute between, or among, the various agencies of government as to whether or not the supply of petroleum products is sufficient for the entire needs of the nation or whether there is actually a shortage of petroleum products at this time" and that "the evidence shows amazing conflicts in the views, opinions, and delegated authority to the various government agencies charged with the expeditious solution of this problem."

The testimony, it was said, shows considerable bootlegging of gasoline in District 1; that equipment for transportation through the Great Lakes routes and barge canals is lying idle and unused, with the government taking no advantage of all the facilities available for movement through the Great Lakes, New York ship canal, Hudson River and Long Island Sound; that while a large number of tank cars have been put to work this merely represents a surplus of equipment in the un-rationed areas, and that public transportation facilities are not adequate for the burden which will be imposed if automobiles are taken off the road.

The committee recommended immediate rationing in that section of District 1 not now covered, and its extension to Ohio, Indiana, Illinois and Michigan "and any other section of the country where transportation other than by pipe line is the means of obtaining petroleum products."

If the Middle West is rationed, it was contended, a surplus of products can be built up in the Great Lakes region for immediate water transportation to the East before winter sets in.

The desirability of centralizing all control of oil was stressed by the group as removing the confusion now caused by conflicting statements issued by the heads of various bureaus.

East Coast Prices Back to June 28 Level

Gasoline prices in District 1 dropped back to their June 28 level August 5 with the lifting by the Office of Price Administration of the 2½-cent per gallon increase which went into effect June 29.

As a result of assumption by Defense Supplies Corporation of the abnormal costs of moving oil into the East by overland facilities, OPA not only eliminated the gasoline-price increase but also cut back consumer prices of kerosine by nine-tenths cent per gallon, distillates and light heating oils by 1.1 cents a gallon and residual fuel oils by 15 cents a barrel, all of which had been raised simultaneously with gasoline.

Except for motor fuel, the full June 29 increase was not revoked, but some of the increase was left in order that the transportation pool, over a period, might recoup the deficit which it has piled up over past months, amounting to some $24,000,000.

Despite the latest OPA action, oil prices in the eastern district remain substantially above those of January 1, last, gasoline being up 1.2 cents per gallon; tractor fuel, gas house oils, distillate diesel fuel oil, and Nos. 2, 3 and 4 fuel oils, 1.5 cents per gallon; kerosine, range oil and No. 1 fuel oil, 1.5 cents per gallon, and residual fuel oils, 30 cents per barrel.

In another sector of the petroleum-price field, OPA ruled that deliveries under sliding-scale contracts for crude during the period on which the petroleum schedule is based, rather than the provisions of the contracts themselves, constitute the price on which ceilings are to be figured.

The ruling was issued on an inquiry as to what constituted the base price for crude oil under a contract in which the price was to be adjusted from time to time to reflect 60 percent of any advance or decline in the posted purchase price, but in no event to exceed 80 cents per barrel, in accordance with which deliveries during the 60 days prior to October 15, 1941, were made at a price of 69 cents per barrel.

"In our opinion," the Price Administration held, "deliveries under this contract during the 60-day period prior to October 15, 1941, must be regarded as sales for the purpose of calculating maximum prices under Section 1340.159 (b)(2) of Revised Price Schedule No. 88, because the contract had the effect of permitting the reflection of changes in the prices of petroleum and/or petroleum products purchased or used by the seller in order to make deliveries under the contract. The term 'sale' in

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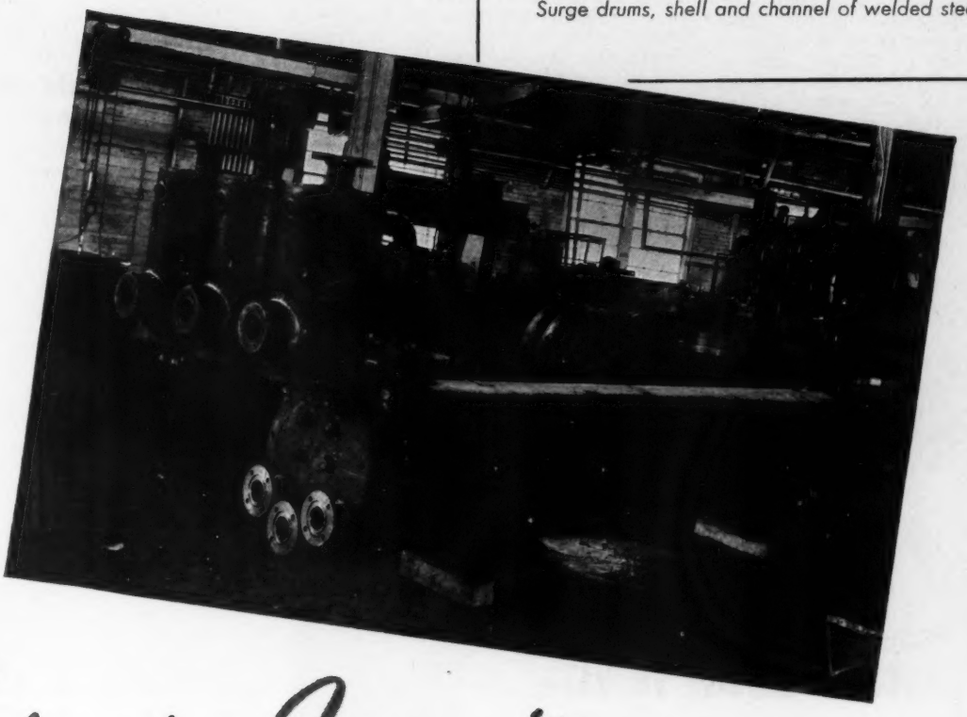

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From the point of view of size and materials required for its construction, this Patterson-Kelley recirculating gasoline cooler isn't what industrial engineers would call a "big" job. But the unique arrangement of its individual surge drums proved to be the *right* answer to the operating conditions it was designed to meet.

You'll like the way Patterson-Kelley engineers approach a problem in the design or construction of a piece of refinery equipment. In the first place, their attitude is that *there is a right answer* to any legitimate problem in engineering—no matter how difficult it may be. In the second place, they give the same careful attention-to-details to a small cooler or condenser that they do to a large interchanger which may require 7,500 square feet of heating surface.

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THE *Patterson-Kelley* CO., INC.

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MANUFACTURERS FOR THE REFINING AND PROCESS INDUSTRIES

that section is defined to include deliveries under such contracts as realistically provide adjustments in placing the parties on a current basis during the said 60-day period.

"It is evident that no provision of the contract operated during the specified 60-day period to prevent such adjustments. Therefore, the maximum price for this fuel oil to this purchaser and any other purchaser of the same class at the shipping point in question is the price charged on the last delivery under this contract within the 60 days prior to October 15, 1941, which we assume from your letter was 69 cents a barrel, reduced by whatever discount for prompt payment was granted in connection with such last delivery."

The Office of Defense Transportation also took action on prices to aid the East Coast, postponing until September 1 new price ceilings on transportation by tank trucks other than common carriers.

D. E. Buchanan Made OPC Houston Director

Appointment of D. E. Buchanan of Tulsa as director in charge of the Office of Petroleum Coordinator District 3 headquarters at Houston, succeeding Grady H. Vaughn, was announced by Deputy Coordinator Ralph K. Davies.

Vaughn, who has been serving also as district director of production, is being transferred to Washington in connection with a nationwide survey of the possibilities of reclaiming oil field equipment for more important war uses in the petroleum industry. The survey will be conducted under the general direction of the production division of the Office of Petroleum Coordinator.

In taking over the job of director in charge of the Houston office, Buchanan will continue also to serve as District 3 director of Natural Gas and Natural Gasoline, a post he has held since last January.

E. O. Buck, of Houston, will succeed Vaughn as district director of production. He has been serving up to now as assistant director of production.

OPC Gives Rules for M-68 Exceptions

Procedure to be followed by members of the natural gas and natural gasoline industries in filing applications for exceptions under Conservation Order M-68 is outlined by OPC, as follows:

Copies of applications are to be forwarded to the Director of Natural Gas and Natural Gasoline, OPC, Washington, in all cases relating to the use of materials in natural gas wells, condensate or distillate wells, and natural-gasoline, pressure maintenance or repressuring plants.

Applications for exceptions in other production branches of the industry will continue to be forwarded to the Director of Production.

In all cases, three copies of the application should be sent directly to the appropriate division in Washington, and a fourth copy should be mailed or delivered to the OPC district director of natural gas and natural gasoline or the district director of production, as the case may be, for the district in which the lease, pool or plant is located.

The procedure applies to all three application forms for exceptions under M-68; Form 214-a is used by operators applying for an exception for an entire pool or drilling program; Form 214-b for an exception to an individual lease, property or well; and Form 214-c for an exception for a cycling or repressuring plant.

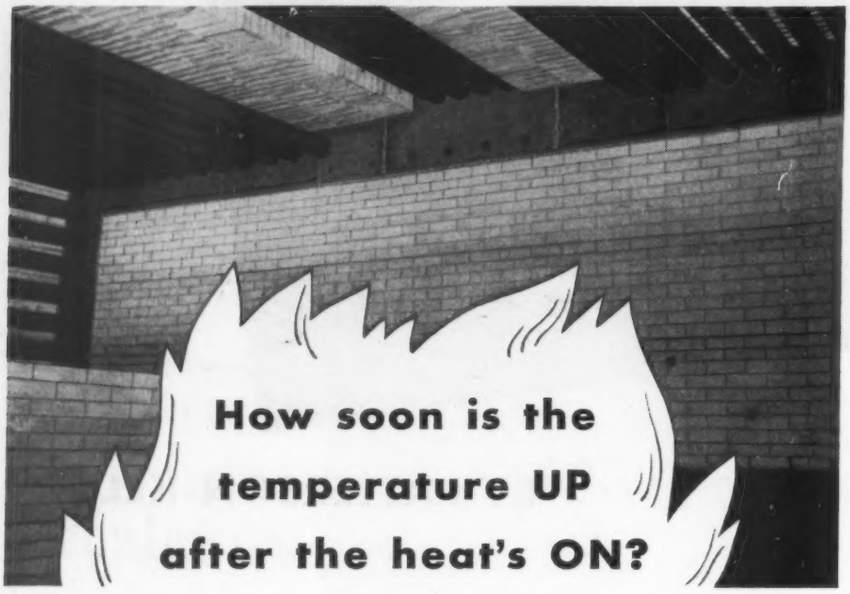
Book on Chemical Refining Revised

"Chemical Refining of Petroleum," by Vladimir A. Kalichevsky and Bert Allen Stagner, published by Reinhold Publishing Company, 330 West Forty-second Street, New York, is a revision of a book published seven years ago and exhausted two years ago. It brings the subject up to date by including the developments and processes that have come about. The attitude of the authors and their method is explained in the preface as:

"The whole book has been revised and much of it rewritten. The patent literature of the first edition proved to be of value and a more nearly complete supplementary list of the United States patents not already discussed in the text has been added."

In addition to the chapter on composition of petroleum the chapters deal with treatment with sulphuric acid, sulphuric-acid sludge and sulphuric-acid manufacture, treatment with alkaline reagents, sweetening operations, refining by adsorption, refining with solvents, detonation, inhibitors, gums in cracked products, deterioration of lubricants and the supplement of United States patents.

The book is available through The Gulf Publishing Company, P. O. Box 2608, Houston, price $7.50.



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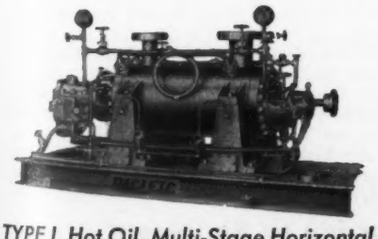
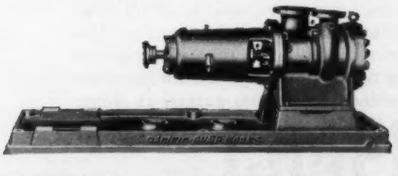
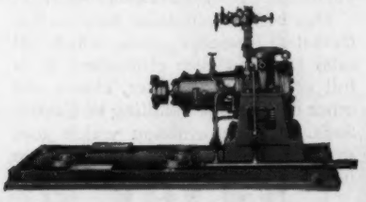
Watch your pumps—watch Pacifics—ask us for service and maintenance counsel. Then after the war when you can replace pumps, we are certain you'll agree—you'll want Pacific.



TYPE I. Hot Oil, Multi-Stage Horizontal, Forged Steel Shell, Double Case, High Pressure Centrifugal Pump.



TYPE RV. Two Stage, Top Suction, Vertically Split Case Centrifugal Pump.



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PACIFIC *Engineered* PUMPS

In Appreciation of Arthur William Nash

In the April issue of "The Naft Magazine," published by Anglo-Iranian Oil Company, London, Dr. A. E. Dunstan pays tribute to Professor Arthur William Nash, who was in charge of the department of Oil Engineering and Refining, University of Birmingham, England. Professor Nash died March 14, age 56, at his home in Solihull.

Among his many contributions to the literature of petroleum refining many were published in REFINER. He was held in high esteem in refining circles in the United States. His career as a scientist in petroleum refining was given by Dr. Dunstan as follows:

"After training as a mechanical engineer at King's College, Strand, he had some experience in dock construction in Hong Kong, and shortly afterwards joined the (then) Anglo-Persian Oil Company and took part in the building of the great refinery in Abadan, South Persia.

"In 1913 he proceeded to the Caucasian oil territory and remained in Russia for over five years, chiefly engaged in field production problems.

"Then began his long and successful career in Birmingham in the footsteps of that great pioneer, the late Lord Cadman, who had founded the first School of Petroleum Technology in the country under his charge as Professor of Mining. When Professor Cadman (as he then was) left, the chair was divided and a separate professorship of oil technology was established, and in 1924 Nash was appointed to the post.

"A very substantial endowment of £125,000 had been raised by the great British oil companies, and Nash's first task was to erect a block of laboratories, offices, museum and library to house his school. This was opened in 1926 and remains as his chief monument.

"During his whole career in Birmingham he was responsible for a constant stream of scientific contributions to oil technology. He was a man of ideas and well able to stimulate his staff and students. With his ample background of first-hand experience in fields and refineries he was well equipped to sense the relative importance of both practical and academic problems, and to direct a vigorous and progressive school of research, whilst in the course of his many visits to centers of oil activity in America, Europe and the East, he made innumerable contacts with the men on the spot, and thus sensed the need for investigation on this or that project.

"Throughout his active life he was intimately concerned with the affairs of the Institute of Petroleum — known, when he became a member in 1914, as the Institution of Petroleum Technologists. For many years he served on the council and as vice president; three years ago he was elected president, and he died in that office. Instances of his contributions to science are to be found in the pages of its journal. But he was a prolific worker, and many of his papers are to be found in American technical journals.

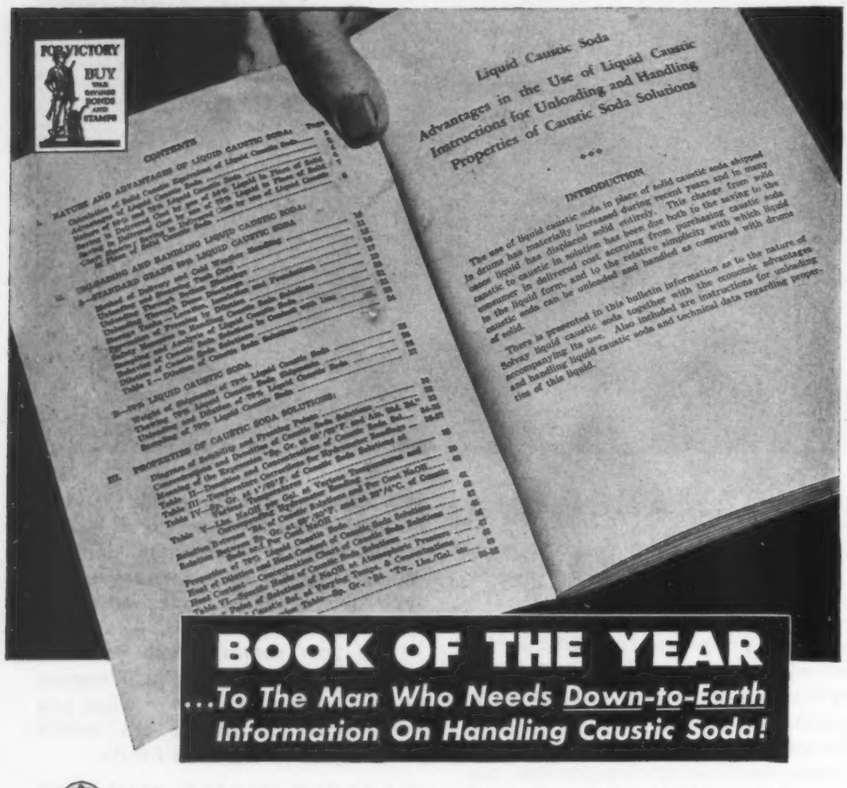
In collaboration with his colleague, Dr. Bowen, he wrote 'The Principles and Practice of Lubrication'; with Dr. Howes, 'The Principles of Motor Fuel Preparation and Application'; and he played a great part in the organization and editing of the four volumes of 'The Science of Petroleum.' His work with Howes on knock-rating of pure hydrocarbons was of great merit; he demonstrated the synthesis of lubricants from the simple olefines by polymerization; with Hunter and Nissan he developed the fundamental study of solvent extraction, the dewaxing of lubricating oil and the refining of waxes. Again with Nissan he published a valuable paper on the relation between viscosity and constitution.

"His presidential address on 'Petroleum as a Raw Material' showed real insight into the ever-growing utilization of oil and its gaseous by-product as raw materials for chemical syntheses.

"This brief note would be very incomplete did the writer not pay a tribute to his old and valued friend and collaborator as a man. Nash had a most lovable nature, and those of us who enjoyed his close friendship for many years feel his passing acutely. Specially will he be missed by his old students who, working in all parts of the world, always kept in touch with him, and were always delighted to visit him on their return home."

Gordon to Represent Tulsa Companies

David L. Gordon, Refiners Export Corporation, Houston, has become associated with Anchor Petroleum Company and Tansel Oil Company, both of Tulsa, in Houston and South Texas. His duties will consist largely in sales of butane and propane in tank cars and large transports. His office is in the Second National Bank building.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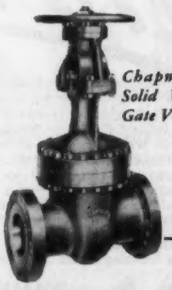
Are *you* taking full advantage of Chapman co-operation and "know-how"? If not, let's talk it over, and see how we can help.



Chapman 900-lb. Solid Wedge Steel Gate Valve.

The **CHAPMAN VALVE**
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Digest of United States Patents On Catalytic Isomerization

HEINZ HEINEMANN

U.S.P. 2,169,494. Treatment of Butane. Vladimir Ipatieff and H. Pines to Universal Oil Products Company.

Activated carbon is coated with anhydrous aluminumchloride and n-butane is passed over this catalyst, eventually in the presence of small amounts of hydrochloric acid at temperatures of about 150° to 250° C. and under pressures of about 10 to 50 atm. Isomerization yields of 53 percent were obtained.

U.S.P. 2,216,221. Catalytic Isomerization of Normal - Paraffinic Hydrocarbons. J. H. Bartlett to Standard Oil Development Company.

It has been known that aluminumchloride and other Friedel-Crafts agents such as $ZnCl_2$, $AlBr_3$, $FeCl_3$, can act as isomerization catalysts. However, most of them require activators like hydrochloric acid to be effective conversion agents. Hydrochloric acid is undesirable because of its high corrosiveness and acidity. It has now been found that halides of boron are excellent activating agents, which can be used in the absence of water and which are less corrosive than hydrogenhalides. A temperature range of 50° to 550° F. is proposed, preferably 150° to 250° F. vapor-phase conversion being employed. A complex of a Friedel-Crafts type catalyst and a metal halide of groups I and II together with a boron halide as an activator can be used.

U.S.P. 2,249,366. Production of Iso-Butane. A. J. van Peski and G. H. Visser to Shell Development Company.

N-butane is isomerized by treating it in either liquid or gaseous phase with a catalyst consisting of or essentially comprising an acid-acting metal halide or a boron halide at a temperature below 100° C.

Another method to isomerize n-butane is to contact it with an aluminumhalide and hydrogenchloride at temperatures below 100° C. and preferably exceeding 70° C. under such pressures as to insure the presence of a liquid phase, the partial pressure of the HCl in the mixture being at least about 3 atm. The catalysts described are selective and no substantial losses due to degradation or polymerization are incurred.

U.S.P. 2,250,410. Catalytic Treatment of Hydrocarbons. A. J. van Peski to Shell Development Company.

Hydrocarbons are treated with a catalyst consisting of an acid-acting halide at a temperature not greater than about 150° C. under a pressure sufficiently high to ensure the presence of a liquid phase in the system and in the presence of a sufficient amount of hydrogenhalide to assure that its partial pressure in the system is at least 3 atm. The hydrocarbons to be converted should boil at a temperature not greater than 160° C. Preferred temperatures are 20-150° C., the reaction time should not exceed 17 hours.

U.S.P. 2,271,043. Isomerization of Hydrocarbons. A. J. van Peski to Shell Development Company.

The object of the invention is to provide a practical and economical process for production of iso-butane and iso-pentane from normal-butane and normal-pentane by catalytic isomerization at a practical rate and with a minimum formation of undesirable products due to side reactions. A further objective is the increase in the life of the catalyst. The isomerization is executed by treating the n-paraffinic hydrocarbon with an acid-acting metal halide at a temperature of below 200° C. in the presence of a hydrogenhalide promoter and between 0.08 and 33 atm. pressure of added hydrogen, the partial pressure of the hydrogen being sufficient to substantially repress undesirable side reactions but insufficient to substantially repress the isomerization reaction.

U.S.P. 2,250,118. Isomerization of Hydrocarbons. W. C. B. Smithuysen to Shell Development Company.

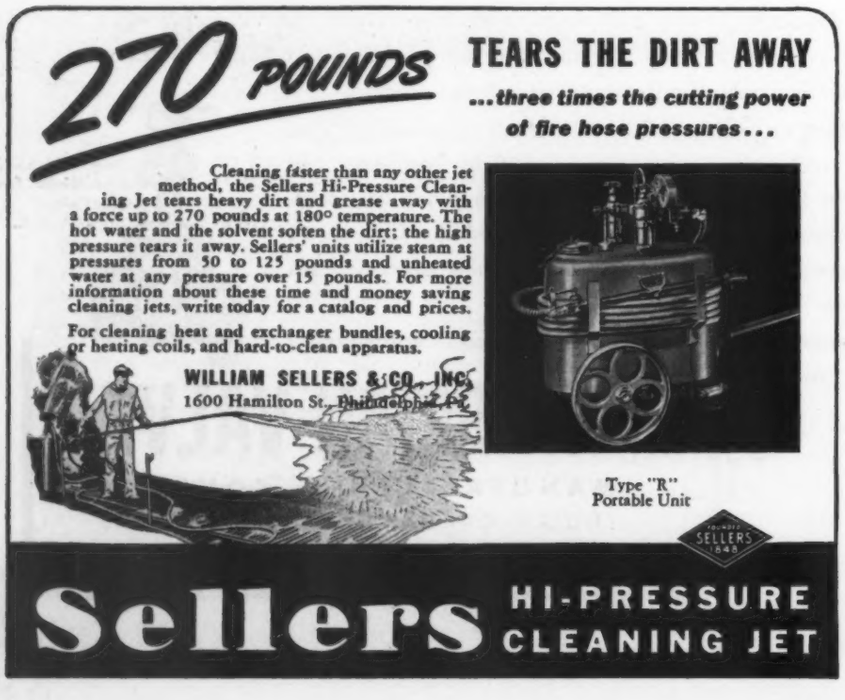
The hydrocarbon to be isomerized or the mixture of such hydrocarbons is contacted in the presence of an inert diluent incapable of isomerization with a catalyst consisting of a double compound of an acid-acting metallic halide with an aromatic compound at a temperature at which isomerization proceeds at a practical rate but below 150° C. for a time sufficient to effect the desired isomerization but insufficient to effect undesired decomposition. The defined catalyst reduces side reactions. The aluminum halide-alkylated aromatic hydrocarbon double compounds are in most cases more or less heavy liquid substances which in case of liquid-phase conversion can be easily added to and contacted with the hyrocarbon to be isomerized. Reaction temperatures of 20° to 140° C. are preferred. A conversion of 18.3 percent of n-pentane was obtained according to one example.

U.S.P. 2,257,896. Catalytic Treatment of Hydrocarbons. W. A. Yarnall to The Texas Company.

The conversion of normal- to iso-hydrocarbons is obtained by using metal halides as catalysts in the presence of small amount of a promoter like HCl, HF, etc. The present invention differs from previous discoveries by the employment of pressures higher than the vapor pressure of the hydrogen halide used at the temperature of operation and by use of sufficient quantities of hydrogen halide, so that the latter serves as a solvent in the liquid phase for the metallic halide. Where the catalyst comprises $AlCl_3$ dissolved in Hcl, the proportion of $AlCl_3$ used may be around 5 to 20 percent by weight of the hydrocarbon treated, preferably about 10 percent. The catalysts are prepared by dissolving a halide selected from the non-gaseous halides of polyvalent metals and metalloids in a sufficient amount of an anhydrous liquefied hydrogen halide to completely dissolve the metal halide and to form an anhydrous liquid catalyst.

U.S.P. 2,265,548. Process for the Production of Iso-Butane. G. C. A. Schuit to Shell Development Company.

The isomerization is carried out by means of a Friedel-Crafts type catalyst supported by a carrier and using a hyrogen halide as a promoter. Particularly effective catalysts are produced when the metal halide catalyst is supported by one of the various silica and/or alumina materials of natural or synthetic origin which contain an appre-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ciable amount of firmly bound water, such as bauxite, fullers earth, bentonite, etc. In order to inhibit side reactions like decomposition and degradation, the isomerization is executed in the presence of a metal like berillium, magnesium, calcium, zinc, iron, copper, silver and especially aluminum. While these metals are preferred, in general all metals which are capable of reaction with a portion of the hydrogen halide present under the reaction conditions tend to be effective to certain various extents.

U.S.P. 2,265,870. Isomerization of Hydrocarbons. G. C. A. Schuit to Shell Development Company.

The same principles embodied in U.S. Patent 2,265,548 are applied to the isomerization of hydrocarbons containing at least five C. atoms.

U.S.P. 2,283,142. Isomerization of Normal-Butane. Vladimir Ipatieff and H. Pines to Universal Oil Products Company.

A process for producing iso-butane is described which comprises subjecting normal butane in the substantial absence of polymerizable olefins to the action of a metal halide catalyst of the Friedel-Crafts type and a relatively small amount of a hydrogen halide under conditions such that isomerization of n-butane constitutes the principal reaction in the process, whereby to convert a major portion of n-butane to i-butane.

U.S.P. 2,283,143. Isomerization of Normal-Butane. Vladimir Ipatieff and H. Pines to Universal Oil Products Company.

Hydrogen chloride is added to n-butane and the resulting mixture is passed through a bed of a relatively inert carrier material containing aluminum chloride under conditions such that isomerization of n-butane constitutes the principal reaction in the process.

U.S.P. 2,266,011. Production of I-Butane from N-Butane. E. L. d'Ouville and B. L. Evering to Standard Oil Company (Indiana).

It is an object of the invention to improve previous processes using $AlCl_3$ catalysts by providing a process with high yields per unit of catalyst consumed and an economical method in preparing a product consisting essentially of i-butane. For this purpose n-butane is subjected at relatively high temperatures and pressures to the action of a catalyst of the $AlCl_3$ type in the presence of an activator and of propane and preferably also in the presence of free hydrogen. Preferred conditions are 350° to 475° F. and 500 to 1000 pounds per square inch. About 1.0 to 5.0 percent by weight of n-butane are charged of the catalyst, and .03 to 3.0 percent of hydrogen halide used as promoter. Propane is added in amounts of 10-50 percent by weight of n-butane to prevent decomposition reactions.

U.S.P. 2,266,012. Production of Branched Chain Paraffin Hydrocarbons. E. L. d' Ouville and B. L. Evering to Standard Oil Company (Indiana).

The teaching of patent 2,266,011 is applied to straight-chain paraffin hydro-

COLMONOY SAVES VITAL METALS

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carbons in a substantially saturated normally liquid hydrocarbon fraction.

U.S.P. 2,286,542. Isomerization of Normal Paraffinic Hydrocarbons. H. Heinemann to Danciger Oil & Refineries, Inc.

A process for isomerizing normal paraffinic hydrocarbons is described, which comprises treating said hydrocarbons at isomerization temperature (100-400° F.) in the presence of a catalytic composition containing a metal halide known in anhydrous condition as a Friedel-Crafts catalyst which has been admixed with an oxygen containing compound of pentavalent antimony selected from the group of antimony oxide compounds obtained by the action of water on a pentahalide of antimony, antimonic acids, and antimony compounds obtained by decomposing an aqueous solution of a salt of an antimonic acid with an acid.

U.S.P. 2,266,401. Isomerization Process. C. N. Kimberlin, Jr., to Standard Oil Development Company.

When using Friedel-Crafts type catalysts and hydrogen halide activators small losses in hydrogen halide occur. In order to replace them and to maintain an even concentration of hydrogen halide small quantities of an alkyl halide are added to the system. The alkyl halide under conditions present in the reaction zone will react with the hydrocarbons present to liberate hydrogen halide in the system. This method offers the advantage that the alkyl halides are usually liquids and easily and cheaply transported and require no pressure containers.

U.S.P. 2,270,669. Process for the Production of Iso-Butane. M. de Simo and F. M. McMillan to Shell Development Company.

The process of this invention consists essentially of contacting a hydrocarbon feed containing propane with a suitable catalyst in the presence of a hydrogen halide promoter under reaction conditions. Iso-butane is produced by one or a series of disproportionation reactions. A supported $AlCl_3$ or other Friedel-Crafts type catalyst is used at a temperature above about 100° C. but not substantially in excess of 200° C. A free metal of the group consisting of aluminum, berillium, magnesium, zinc, copper, iron may be added to the aluminum halide.

U.S.P. 2,279,291. Isomerizing Hydrocarbons. H. A. Cheney to Shell Development Company.

The use of liquid aluminum halide catalysts has been investigated. The aluminum halides per se when used in a molten state are unsuitable because at temperatures above their melting point they cause almost complete degradation of the hydrocarbons. Aluminum halide easily forms double salts as $AlCl_3$, NaCl, $AlCl_3 \cdot LiCl$, etc., and these were found active in a molten state only if containing an excess of aluminum halide. Further activation can be obtained by using a promoter, consisting of the halides of the purely nonmetallic and semi-metallic elements of group 6 which constitute the sulphur group. Amounts of .3 to 10 percent of the promoter are used.

U.S.P. 2,274,624. Vapor-Phase Isomerization of Hydrocarbons. F. M. McMillan to Shell Development Company.

It is known that when isomerizing with a Friedel-Crafts type catalyst in the presence of hydrogen halide, the concentration of hydrogen halide should be relatively small below about 10 percent and in the majority of cases below 5 percent to avoid excessive degradation. The inventor has found, however, that this is true only for fresh and relatively active catalysts and that as the reaction progresses greater and greater concentrations of hydrogen halide may be employed without harm. Higher overall yields are obtained by slowly but constantly increasing the amounts of hydrogen halide while always keeping them below those causing excessive degradation.

U.S.P. 2,277,022. Method for Executing Catalyzed Vapor-Phase Reactions. F. M. McMillan and G. S. Parsons to Shell Development Company.

The isomerization of n-butane is carried out by passing butane vapors together with $AlCl_3$ and hydrogen halide vapors over a bed of adsorptive alumina at a temperature above 230° C. but below that causing substantial cracking, and recovering and recycling $AlCl_3$ and hydrogen halide.

U.S.P. 2,225,776. Isomerization of Paraffins. A. V. Grosse and H. Pines to Universal Oil Products Company.

Zirconium chloride and hydrogen chloride are used as catalysts for the isomerization of hydrocarbons and hydrocarbon mixtures. The process can be

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operated in either liquid, mixed or vapor phase. The zirconium chloride is used in granular form and in amounts of 5 to 10 percent. Superatmospheric pressure may be employed.

U.S.P. 2,273,159. Isomerization of Normal-Pentane. C. O. Tongberg, C. S. Lynch and J. H. Bartlett to Standard Oil Development Company.

As compared with the isomerization of n-butane, n-pentane presents an entirely different problem. Reaction conditions are relatively mild because n-pentane can isomerize or crack to a greater variety of products than n-butane. High temperatures are detrimental to isomerization of n-pentane. According to the present invention, n-pentane is isomerized to i-pentane to 70 to 80 percent with a minimum amount of cracking. A C_5 paraffinic hydrocarbon composition containing more than 10 percent of n-pentane is contacted with 100 percent (weight) of $AlCl_3$ based on the total hydrocarbons present, in the presence of at least one hydrogen halide. The mixture is agitated at at least 30° F. but at a temperature low enough to insure liquid-phase operation for a period sufficient to effect at least 60 percent (volume) of iso-pentane based on normal-pentane charged. Between 3 and 22 percent (weight) hydrogen halide is added, the reaction time being .75 to 20 hours.

ISOMERIZATION OF OLEFINS

U.S.P. 2,216,284. Isomerization of Normal-Olefins. C. L. Thomas and H. S. Bloch to Universal Oil Products Company.

Relatively straight chain n-olefinic hydrocarbons are passed at elevated temperature and moderately superatmospheric pressure over catalytic materials comprising synthetically prepared calcined composites of hydrated silica, hydrated alumina and hydrated thoria producing high yields of iso-olefinic hydrocarbons. Synthetically prepared composite masses of hydrated silica, hydrated alumina and hydrated zirconia can also be used. Preparation methods are given. The character and efficiency of the silica - alumina - thoria catalysts will vary with methods of precipitation, mixing, purification, treatment, ratio of components, calcining, etc. For maximum activity calcination should take place at 850 to 1000° F. or higher. Isomerization reaction takes place at 400 to 1050° F. and atmospheric to slightly elevated pressure. In converting n-pentene at a space velocity of 3, a 59 percent yield of iso-pentene was obtained.

U.S.P. 2,216,285. Isomerization of Normal-Butene. C. L. Thomas and H. S. Bloch to Universal Oil Products Company.

Conversion of n-butene at elevated temperatures and atmospheric pressure by synthetically prepared calcined mixtures of the hydrogels of silica (SiO_2), alumina (Al_2O_3) and thoria (ThO_2) is described. Some polymerization occurs as side reaction and polymers have to be separated from the finished product. At 842° F., a space velocity of 885, an isomerization of 20.3 percent and a polymerization of 11.2 percent were obtained. Reactions under various conditions are described.

U.S.P. 2,217,252. Process for Isomerization of Olefinic Hydrocarbons. Han Hoog to Shell Development Company.

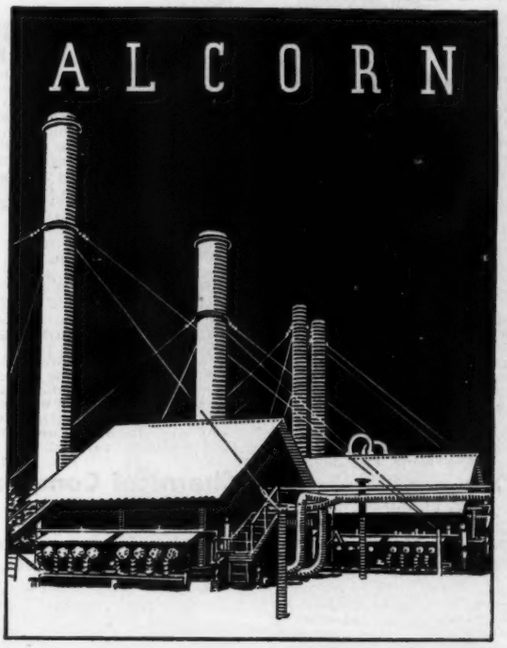
The process of the invention comprises contacting the olefin to be isomerized alone or in admixture with other olefins and/or in the presence of one or more substantially inert diluents such as saturated hydrocarbons, aromatic hydrocarbons, nitrogen, etc., with a solid catalyst consisting of a hydrated aluminum silicate of the permutite or zeolite type at a temperature of from about 275 to 500° C. The reaction rate has to be selected so as to give maximum isomerization while substantially suppressing polymerization and other side reactions. Conversions of from 30 to 55 percent are claimed. Reaction times used are from 10 to 250 seconds.

U.S.P. 2,220,693. Isomerization of Olefins. A. J. van Peski and H. F. J. Lorang to Universal Oil Products Company.

The process of the invention comprises contacting a normal-butene, a mixture of normal-butenes or a hydrocarbon mixture containing substantial amounts of butenes with a catalyst consisting of a phosphorus-oxy acid at temperature of from 250 to 550° C. for 2 to 30 seconds or such time as will be sufficient for substantial isomerization but insufficient for polymerization.

U.S.P. 2,281,804. Isomerization of Olefins. Robert F. Ruthruff.

In a process for the conversion of a normal-butene to iso-butene it is claimed as new to contact said n-butene with a stabilized pyrophosphate of a metal selected from the group consisting of copper, mercury, zinc, iron, aluminum, cobalt, and magnesium at a temperature of from 250 to 450° C. for a time period and under a pressure such that the isomerization of the normal-butene proceeds at a substantially higher rate than the polymerization of butenes.



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Fundamental Physical And Chemical Data

Phase Equilibria in Hydrocarbon Systems. B. H. SAGE AND W. N. LACEY, *Ind. & Eng. Chem.* **34** (1942) pp. 730-37.

The specific volume of n-pentane was determined at pressures from near atmospheric to 10,000 pounds per square inch at ten temperatures between 100° and 460° F. The vapor pressure of n-pentane was determined at nine temperatures in this interval, and the volumetric behavior in the critical region was studied in detail. Enthalpy-pressure coefficients in both the gaseous and liquid regions were calculated from the volumetric data. Previously published work on the thermodynamic properties of n-pentane is reviewed. From the experimental data and pertinent published data, values of isothermal enthalpy changes and of the fugacity of n-pentane were calculated throughout the above-mentioned ranges of temperature and pressure. The results are presented in tabular form, and diagrams illustrating the behavior of the hydrocarbon are presented. A bibliography of 18 references is included.

The Indirect Estimation of Critical Temperature and of Molar Refractivity, R. LIVINGSTON, *J. Phys. Chem.* **46** (1942) pp. 341-3.

The critical temperature and molecular refractivity are linear functions of the normal boiling point for homologous series of hydrocarbons, alcohols, ethers, acids, esters and nitriles. If the range of temperature is very great, a small quadratic correction term must be used. Values of the constants of the equations are given in tabular form. The relationships also apply to the series of inert gases. The author states that the relations can be applied more readily and appear to be more nearly exact than those presented by Wan.

Molecular Refraction—Critical Temperature Nomograph, D. S. DAVIS, *Ind. & Eng. Chem.* **34** (1942) p. 689.

For members of six important organic series it has been shown by Wan that the critical temperature is a linear function of the molecular refraction according to the equation:

$$t_c = k_1 R + k_2$$

The values of the constants k_1 and k_2 are given for the different chemical series. The author presents the nomograph from which critical temperatures can be read conveniently from the line coordinate chart by aligning the molecular refraction of a member with the series number and producing the line and extending the line to the critical temperature scale. A typical example is given. Ethyl propyl ether would cause a molecular refraction of 27.2. It belongs to series 4, has a critical temperature of 225° C. as determined from the nomograph. The observed value as given in the International Critical Tables is 227.4° C.

Molal Volume Relationships Among Aliphatic Hydrocarbons at Their Boiling Points, G. EGLOFF AND R. C. KUDER, *phys. Chem. J.* **45** (1941) p. 836; *J. Inst. Petr.* **27** (1941) pp. 260-274.

The molal volumes at their boiling points of 63 aliphatic hydrocarbons in 14 different homologous series were correlated with a number of carbon atoms in the molecule by means of equations of the type

$$V = a(n + 4.4)^c + K$$

in which a, c and K are constants, and n is the number of carbon atoms in the molecule. The deviation of the calculated from the observed values is approximately 0.3%. The boiling-point molal volume of 43 aliphatic hydrocarbons in 9 homologous series were correlated with the boiling point. By means of equations of the type

$$\text{Log } (V - K) = At + B$$

in which K, A and B are constant, and t is the boiling point in °C., the deviation is 0.5% to 0.6%. The effect of the molecular structure on the boiling-point molal volume is considered.

Frictional Phenomena, I. A. GEMANT, *J. Appl. Phys.* **12** (1941) p. 530.

This article is one in a series that will eventually be published in monograph form covering viscous and related frictional forces. The fundamental mathematical friction equations are discussed and their application to flow between parallel walls is considered.

Chemical Compositions And Reactions

Higher Hydrocarbons. I. Seven Alkyl Substituted Docasanes, F. C. WHITMORE, L. H. SUTHERLAND AND J. N. COSBY, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 1360-4.

Although much work has been done on the systematic study of the lower molecular weight hydrocarbons, there is little accurate information on hydrocarbons containing over twenty carbon atoms. In the course of the work seven simple isoparaffins from C_{26} to C_{32} were prepared and studied. Four of these had a straight C_{22} chain with n-butyl groups on the fifth, seventh, ninth, and eleventh carbon atoms, respectively. The other three had the same C_{22} chain, but with n-hexyl, n-oxtyl, and n-decyl groups on the seventh, ninth, and eleventh carbon atoms, respectively. Methods of separation and purification of the compounds are described. The properties of substances are given in tabular form, including melting point, boiling point, refractive index, density, molecular refraction, and viscosity.

Studies in Gaseous Hydrogenation and Polymerization Reactions, H. D. BURNHAM AND R. N. PEASE, *Jour. Amer. Chem. Soc.* **64** (1942) pp. 1404-10.

Studies were made of the polymerization of ethylene, acetylene, and propylene, and of the hydrogenation of ethylene and propylene. It was found that the polymerization reactions of ethylene and of acetylene and the hydrogenation reaction of ethylene are inhibited by small initial additions of nitric oxide. The results are interpreted as indicating a chain mechanism for the above reactions, and that the nitric oxide acts by combining with the free radicals or atoms and effectively prevents their further participation in the chain reaction. The polymerization and hydrogenation reactions of propylene were found not to be inhibited by small additions of nitric oxide. On the contrary, a slight acceleration of these reactions is caused. Although no explanation is offered, it is pointed out that this is only one of the instances in which the reactions of ethylene differ widely from the corresponding reactions of its next higher homolog, propylene.

Catalytic Polymerization of Olefins in the Presence of Phosphoric Acid, A. FARKAS AND L. FARKAS, *Ind. & Eng. Chem.* **34** (1942) pp. 716-21.

The polymerization of isobutene and other olefins, using a phosphoric acid catalyst in which the hydrogen atoms were replaced by deuterium atoms, was investigated. The polymerization proceeds readily even at room temperature and leads to polymers that contain deuterium. Polymerization is accompanied by an exchange of hydrogen atoms between the catalyst and isobutene. n-Butene polymerizes less readily than isobutene. The reactions of propene and ethylene are still slower. No exchange of isobutene was observed, although diisobutene polymer can undergo further exchange when brought into contact with the deuterated catalyst. The mechanisms of polymerization as proposed by various authors are discussed. The authors suggest a modified form of Ipatieff's mechanism. According to this, the catalyst and the olefin molecule can combine to two different forms, one of which results from the transfer of one hydrogen atom from the catalyst to the olefin, while the other is formed by the transfer of a hydrogen atom from the olefin to the catalyst. The polymer is formed by the interaction of these two forms. The suggested mechanism explains the experimental results of polymerization and exchange satisfactory. The apparatus and procedure used are described, and the data secured in the work are presented in tabular and graphical form.

Mechanism and Kinetics of Additions to Olefinic Compounds, G. WILLIAMS, *Trans. Faraday Soc.* **37** (1941) pp. 749-63.

Halogen addition to olefins represents attack by positive polarized halogen upon a negative center at one of the unsaturated carbon atoms. No conditions have been realized that permit addition of the halogen to a double bond to proceed through the union of isolated halogen and olefin molecules as a meeting in binary collision. There is a distinction between the addition reaction in dissociating solvents and in nondissociating solvents. In the former halogen addition is definitely 2-stage. The author reviews 13 reactions in dissociating solvents. These are shown to be homogeneous, reproducible and insensitive to stray catalysts. Addition takes place most readily by the ionic mechanism in strongly dissociating solvents, and less readily in dissociating solvents such as acetic acid by a 2-stage mechanism, and usually still less readily in nondissociating solvents by catalytic mechanisms.

Manufacture: Processes and Plant

Determination of Salts in Crude Oil, C. A. NEILSON, J. STEWART HUME, AND B. H. LINCOLN, *Ind. & Eng. Chem., Anal. Ed.* **14** (1942) pp. 464-5.

Salts in crude oil contribute to the mechanical clogging of furnace tubes, condensers, and lines to the corrosion of equipment by the hydrolysis of salts producing hydrogen chloride, and cause high ash content of still residues. A simple and rapid method for the quantitative extraction of inorganic salts from crude oils is presented, in which phenol is used as the destabilizing agent. Provision is made for the separation of hydrogen sulfides and mercaptans, a precaution not taken

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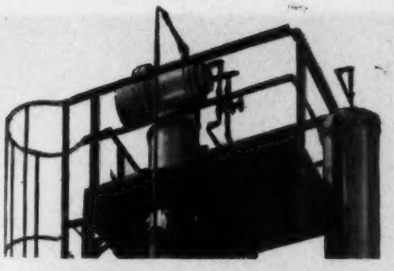

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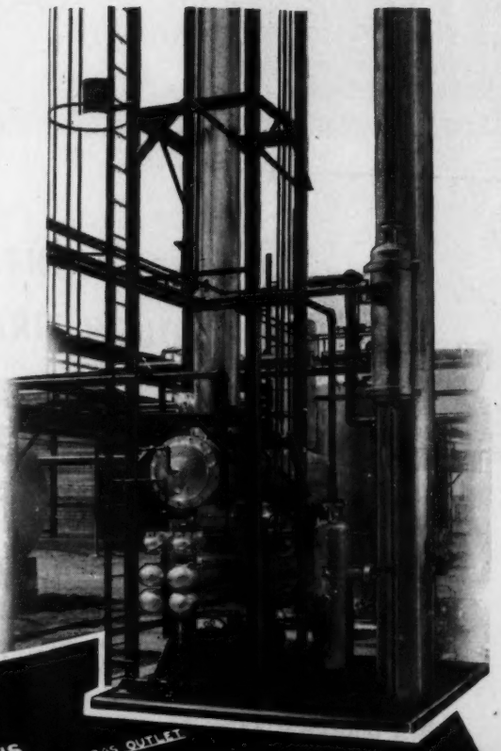

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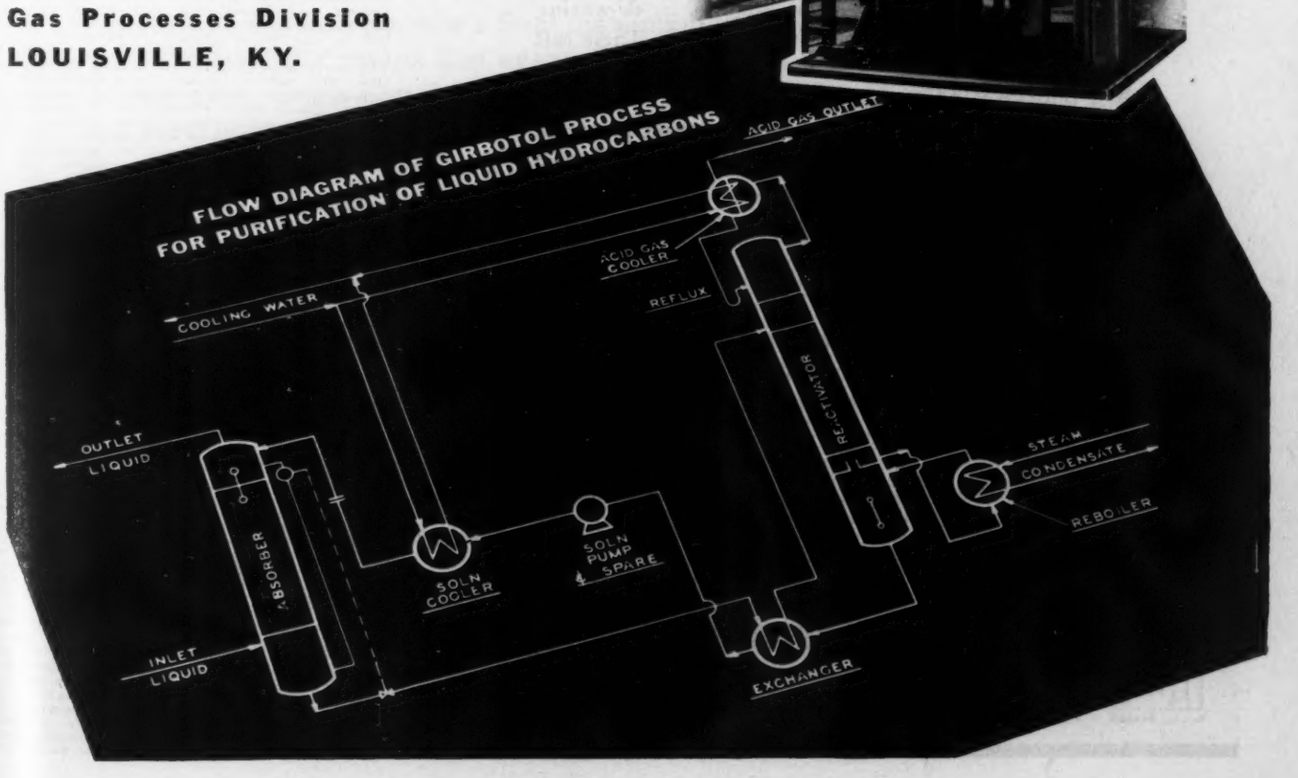

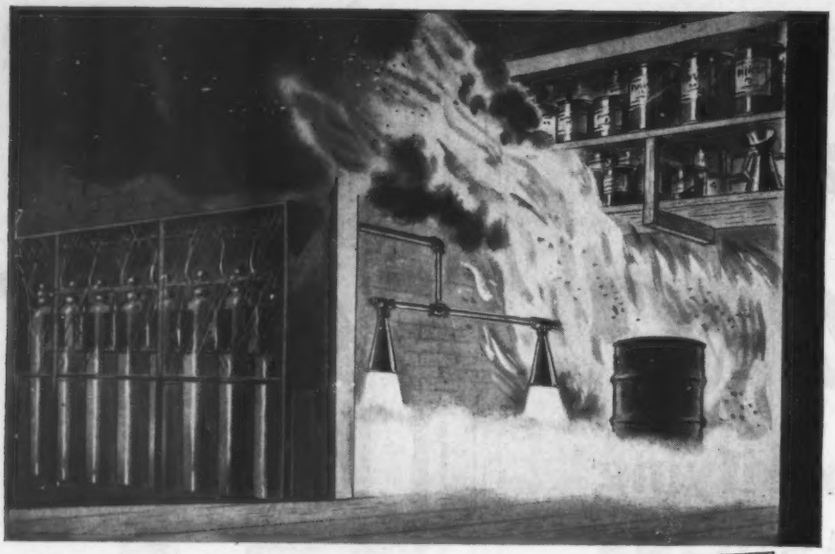

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in some of the common methods for salt extraction and analysis. Details are given for easy regulation of the pH in the determination of extracted chlorides by the Mohr titration in the presence of phenol. A formula is given for a simple and generally useful universal indicator to be used in the procedure.

Column Packing and the Separation of Isotopes, H. G. THODE AND F. O. WALKLING, *Can. J. Research* **20,B** (1942) pp. 61-8.

The authors investigated a packing material for fractionating columns comprising expanded shale aggregate. This packing is inert, cheap, and easily wetted by water. Columns packed with the material have been tested in distilling hydrocarbons and with water systems. The new packing compares favorably, both with regard to efficiency and throughput, with other column packings, and is more efficient for the water systems. It is believed that it should have industrial applications as well as use in the separation of isotopes.

Interconversions of Binary Compositions by Simple Graphical Methods, K. HAN SUN AND A. SILVERMAN, *Ind. & Eng. Chem.* **34** (1942) pp. 682-4.

In general there are two ways of expressing the composition of a system: (a) in parts by weight or volume, or in numbers of moles; and (b) in fractions or percentages by weight, volume, or moles. Conversion of either to the other is an almost daily routine for chemical engineers dealing with problems on absorption, distillation, and the like. The methods discussed in the article for the making of the conversion are believed by the authors to be more comprehensive, simpler, and perhaps more accurate than previous methods. The methods have been applied to actual problems and have been found to require less than half the time necessary for the making of the conversion by slide rule calculation. Because of their simplicity these graphical methods induce less error than numerical calculation. The methods are described in detail, and illustrated by typical problems.

Liquid-Liquid Extraction in a Perforated Plate Tower, R. E. TREYBAL AND F. E. DUMOULIN, *Ind. & Eng. Chem.* **34** (1942) pp. 709-13.

The investigation reported was concerned with the extension of the present knowledge of the performance of liquid-liquid extraction equipment. Several recent articles have shown that in liquid-liquid extraction a large percentage of the change occurring is completed upon the formation of the drop, or within a short time after it starts to travel. It follows that not only is it desirable to deform and distort the droplets of the dispersed phase after they have been formed, but it may be of greater importance to reform the droplets as frequently as practical. The perforated plate tower should accomplish this. The authors made liquid extraction of toluene-benzoic acid solutions by means of water. These were effected in a perforated plate tower with the toluene solution dispersed. The tower was 3.56 inches in diameter. The operating behavior of the column is discussed. The design of the plates has a marked effect on the permissible solvent throughput. Over-all extraction resistances and coefficients for three different plate spacings are reported. The improvement of these values over those previously reported for similar apparatus is laid to small differences in plate design. Data are reported for rates of extraction at various flow rates and at plate spacings of 3, 6, and 9 inches. Decreasing the plate spacings improves the extraction efficiency but decreases the throughput permissible without causing flooding. The $K_w a$ values for 3-inch spacing are affected by both solvent rates, but for 6-inch and 9-inch spacings are independent of water rate over the range of flows studied.

Liquid-Liquid Extraction Data, D. F. OTHMER AND P. E. TOBIAS, *Ind. & Eng. Chem.* **34** (1942) pp. 690-2.

Bhatnagar and Ward have used anhydrous acetic acid as the solvent in the extraction of aromatics from straight-chain hydrocarbons in the purification of petroleum fractions, because of its preferential solubility for the former and substantial immiscibility with the latter. The authors desired to determine the usefulness of acetic acid as an extracting solvent for toluene made by the reforming of seven-carbon aliphatic hydrocarbons from the excess seven-carbon aliphatic hydrocarbons having substantially the same boiling points. As representative of the seven-carbon aliphatic hydrocarbons, n-heptane was used as the diluent or liquid in which the toluene is regarded as being originally dissolved. Anhydrous acetic acid is completely miscible with toluene and n-heptane at ordinary temperatures, and a fourth liquid, water, was added in small amounts. Solubility

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diagrams for the system are presented in the article.

Isolation of Sulfur Compounds from a California Straight-Run Gasoline, O. L. POLLY, A. C. BYRNS, AND W. E. BRADLEY, *Ind. & Eng. Chem.* **34** (1942) pp. 755-8.

Aluminum chloride was found to remove sulfur compounds practically quantitatively from high sulfur naphtha, and to form a heavy fluid sludge that was readily separated from the naphtha. The investigation reported was undertaken to examine a product obtained by treating high-sulfur naphtha with aluminum chloride at ordinary temperature. Hydrolysis of the sludge was found to liberate an oil that contained 20 weight percent of sulfur. Seventy percent of the oil boiled in the original naphtha range. Close-cut fractions from this material yielded several thiophanes identical with those previously reported in the literature. The gasoline selected for extraction in the work was a typical straight-run naphtha obtained from Santa Maria Valley, California, crude. The total sulfur content was 0.39 percent by weight. Improved methods for segregating individual sulfur compounds are given and discussed.

Electrical Charges Produced by Flowing Gasoline, S. S. MACKEOWN AND V. WOUK, *Ind. & Eng. Chem.* **34** (1942) pp. 659-664.

The work reported was undertaken to determine the magnitude of electrical charges that can be produced in the handling of gasoline. The flowing of gasoline in pipes generates static electrical charges that are sometimes capable of producing a spark that may ignite a combustible mixture of gasoline vapor and air. Although suitable precautions have ordinarily been taken in the oil industry to prevent the accumulation of these charges and eliminate the hazard caused by them, very little is known regarding the magnitude of the charges. Measurements were made on the charges produced when gasoline was pumped from a filling rack to a tank truck, when the truck was unloaded at a service station, and when an automobile received gasoline at a service station. The measurements were made under normal operating conditions. Abnormally large amounts of moisture in the gasoline might alter the results. Data are given in the article on the currents produced and the voltages resulting under various conditions. The hazards involved are discussed.

Guarding Against the Flammable Liquid Fire Hazard, C. L. GRIFFIN, *Ind. & Eng. Chem.* **34** (1942) pp. 664-69.

The flammable liquid fire hazard is chief among the threats that menace the process industries. The storage, processing, and testing of flammables present a serious problem in industrial fire protection. The automatic detection of fire can be handled in several effective ways that are briefly discussed. The article is largely devoted to the question of the use of carbon dioxide gas in snuffing fires. Although portable carbon dioxide extinguishers will fill an important first-aid function in fire fighting, the article is concerned mainly with built-in carbon dioxide fire extinguishing systems. Importance of the manner of release of carbon dioxide through the use of special nozzles is emphasized.

Some Factors Covering the Stability of Oil-in-Water Emulsions, A. KING, *Trans. Faraday Soc.* **37** (1941) pp. 168-180.

The stability of the emulsion can only be effectively measured by the rate of coalescence of the disperse phase. There are three basically different types of emulsions: (1) oil hydrosols (unstabilized), (2) those stabilized by electrolytes, and (3) those stabilized by materials such as colloidal materials or finely divided solids. The stability of an emulsion is not necessarily a function of the degree of dispersion—e.g., coarse emulsions made with gelatinous alumina are stable for years. Low interfacial or surface tensions are not important factors in stability, but only the adsorption that accompanies them. If there is no chemical reaction between electrolyte and emulsifying agent, the electrical charge on the dispersed phase does not determine stability or type. High viscosity is not a cause of stability. Densities and chemical properties of the two phases affect ease of emulsification and stability. The effect of temperature is specific for the different types of emulsions, and cannot be used as part of an accelerated method of stability comparison. Method of preparation has a large effect—e.g., homogenization compared with hand-shaking for soap emulsions gives ten times the specific area of interface and 1.8 times the stability. It has been found that sodium oleate increases the power of carbon black to give more stable water-oil emulsions. The author concludes that the strength and compactness of the interfacial

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film are really the most important factors favoring stability.

Sulphur from Arkansas Sour Gas, J. A. LEE, *Chem. & Met. Engr.* **49** (1942) pp. 80-82.

The recently developed gas fields in southwestern Arkansas are characterized by the production of a gas that contains an unusually large hydrogen sulphide content. Through the efforts of the Texas Gulf Sulphur Company it has been demonstrated that this hydrogen sulphide can be the source of a supply of elemental sulphur for the chemical industry of the state. The presence of hydrogen sulphide has prevented the marketing of the gas and in turn has prevented the production of petroleum condensate, natural gasoline and other hydrocarbons. The hydrogen sulphide content of the gas varies from 30 to 4500 grains per 100 cubic feet. Gas containing 360 grains of hydrogen sulphide per 100 cubic feet may not be objectionable when used directly as boiler fuel gas. However, for domestic purposes gas containing more than 1½ grains of hydrogen sulphide per 100 cubic feet is not permitted because of the corrosive effect. The hydrocarbons exist in the wells in a homogeneous vapor phase at pressures above 4000 pounds per square inch. It is brought to the surface and the pressure reduced to 800 pounds per square inch, retrograde continuous condensation of heavier hydrocarbons taking place. The distillate is separated at this pressure. The raw gas at separator pressure or upon recompression passes to the Girbotol plant where it is purified by a water solution of monoethanolamine. Gas containing as high as 5000 grains of hydrogen sulphide per 100 cubic feet will be treated and the H_2S content reduced to less than 0.1 grain per 100 cubic feet, which meets the standard for sweet gas. After purification the gas flows to the gasoline recovery plant where natural gasoline and butanes are separated. The gas is then dehydrated to remove water to such point that no difficulty will be had in transmission on account of the formation and accumulation of hydrocarbon hydrates. The dehydration unit employs a solution of amines and glycols which is effective in removing water vapor. The effluent from the Girbotol plant, which contains an average of 58 percent by volume of hydrogen sulphide, 41 percent of carbon dioxide and 1 percent of hydrocarbons on the dry basis, passes to a second pilot plant for the conversion of hydrogen sulphide to elemental sulphur. The sulphur dioxide is formed by partial combustion of the H_2S, and this sulphur dioxide is then reacted with hydrogen sulphide to form water and sulphur. The results of the pilot plant work have demonstrated that more than 80 percent of the sulphur in the hydrogen sulphide can be easily and effectively recovered in the form of sulphur. The total hydrogen sulphide available from the gas fields, according to present estimates, may be equivalent to more than 100 net tons of sulphur per day.

The Effects of Exposure to Toluene in Industry, L. GREENBURG, MAY R. MAYERS, H. HEIMANN AND S. MOSKOWITZ, *J. Am. Med. Assoc.* **118** (1942) pp. 573-8.

The inhalation of toluene in concentrations of 100-1100 parts per million over a period of 2 weeks to more than 5 years results in enlargement of the liver, macrocytosis, moderate decrease in number of red cells with absolute lymphocytosis, but not leucopenia.

Products: Properties And Utilization

1940 Road Detonation Tests, J. M. CAMPBELL, R. J. GREENSHIELDS, AND W. M. HOLADAY, *J. Soc. Aut. Engrs.* **48** (1941) pp. 193-204.

The paper is a compilation of the Report of the C.F.R. Committee on the program of cooperative road tests. These tests indicated that the A.S.T.M. octane number alone, or even a road octane number as determined by methods widely used heretofore, does not give the required information for present needs relative to the service behavior of fuels. Also, the test methods used to date do not provide sufficient information with regard to fuel requirements and knocking characteristics of engines. A new method has been developed, in which the spark advance corresponding to incipient or border-line knock is determined for the fuel under test at frequent increments of speed; these observations were made on a range of cars during full throttle acceleration on a slight upgrade, using 23 representative fuels as well as the necessary range of reference fuels. The spark advance readings are plotted against speed for each car, both for the reference and test fuels. The fuel test data are interpolated on the reference fuel framework, and in this manner the octane number of the test fuel is determined for any desired speed. Also, by plotting a previously determined curve of spark advance for maximum power and the characteristic curve of the distributor automatic advance it is possible to determine (1) the car octane requirement over the whole speed range, and (2) to what extent a given fuel meets the car's requirements. In the past it has been the practice to advance the ignition timing beyond that of maximum power in order to evaluate fuels of high anti-knock quality. Tests with low- and high-compression heads showed that such a rating is not indicative of the performance in an engine designed to utilize the fuel effectively. Data are included in the article on 23 representative fuels, and the applications of the method to fuel and engineering development are discussed.

British Methane — An Alternative Fuel, ANON., *Petroleum* **4** (1941) p. 64.

Methane has a high octane number and can be used at a compression ratio of 17-20. It can be used in gas-bags on the roof of cars in a manner similar to town gas, or can be compressed into cylinders at 3000 pounds pressure. The normal-size cylinder of gas is equivalent to 2½ gallons of gasoline. If methane could be transported as a liquid, wide possibilities would be open for this fuel. It is suggested that methane could be used for locomotives, as in Italy, and numbers of other possibilities are suggested, particularly for use of gas in liquid form. The sources of methane in England are: gas escaping from coal in collieries, from bacterial treatment of sewage, from combustion of coal in coke-ovens and gas-works.

Specification for Asphalt Enamel Protective Coatings for Steel Water Pipe, ANON., *Asphalt Institute Construction Series No. 55* (1941).

Specifications are given for asphaltic primer, asphaltic dip, asphaltic enamel, and bitumen-saturated asbestos-felt wrappers for protective coatings for steel water-pipe. Methods of application of the materials and methods for the determination of performance characteristics of the enamel are included. The performance tests are made using specimens prepared on mild-steel plates to which the enamel has been applied after sand blasting and treatment with primer. The tests include high- and low-temperature sag tests, peel

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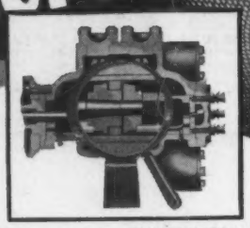

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Asphalt Protective Coating for Steel Water Pipes, A. H. BENEDICT, *Eng. News-Record* **128** (1942) pp. 327-9.

The extensive study conducted by the Asphalt Institute at San Francisco is summarized. To have corrosion the metal must be in direct contact with a corrosive environment and moisture and oxygen must be present. The protective coating must, therefore, maintain a continuous membrane capable of excluding all corrosive agents. Studies have shown that water absorption as determined by the soaking test is not a measure of the water that will diffuse through a bituminous film. The quantity of water that will permeate an intact asphalt coating is not sufficient to support corrosion. Bituminous materials were found to be much less permeable to oxygen and other gases than to water. A tabulation is included of the results of tests to determine the relative ratings of 4 asphalt coatings. The basic requirements of the Institute's specifications are: softening point 220-260° F., penetration at 77° F., 3-12 cm., ash 10-35% by weight. The other tests refer to performance in service, namely: sagging at high temperature, cracking or disbonding at low temperature, resistance to peeling, impact and soil stress, and solubility. Softer enamels are superior in resistance to vibration, but too high a penetration value results in a product that is increasingly susceptible to damage by hard objects and by distortion under soil stress. As a result of the studies, specifications were adopted for priming materials, enamel coatings, application methods, wrapping with asphalt saturated salts, and performance test procedures.

A.S.T.M. Standards on Petroleum Products and Lubricants, September, 1941, pp. viii + 398. $2.00 per copy.

This is the 16th edition of this publication, issued annually by the American Society for Testing Materials since 1926. It provides in compact form testing methods, specifications, definitions, and charts developed through the work of A.S.T.M. Committee D-2 on Petroleum Products and Lubricants. This edition includes 69 methods of testing, 11 specifications, and 2 lists of definitions of terms. There are four proposed new methods covering tests for neutralization number (by electrometric titration, and for crankcase oils), potential gum in aviation gasoline, and conversion of kinematic to Saybolt Furol viscosity. A revised diesel fuel-oil classification is given. Among the important new standards in the volume are specifications for aviation gasoline and tests for knock characteristics of aviation fuels, standardized method of determining the ignition quality of diesel fuels, and procedures for testing the aniline point of petroleum products and for carbonizable substances in paraffin wax. Thirteen standards were revised during the year.

Steam versus Diesel-electric Locomotives, E. E. CHAPMAN, *Engineer* **172** (1941) pp. 101-103.

The general dimensions and power performances of certain American diesel-electric locomotives and comparable conventional steam locomotives are given. The advantages claimed for the diesel-engined type are: high thermal efficiency, low water costs, high degree of utilization and flexibility, reduction of delay in taking fuel and water, sustained high speeds, lower stresses imparted to track structure, and dynamic braking. The disadvantages are: high initial investment cost, lower life expectancy, demand for high degree of maintenance, higher unit cost of fuel and lubrication. A resume is given of the accomplishments to date of diesel-electric locomotives in main-line service. It is not suggested that they will entirely displace the constantly improving steam locomotive, but, as more and more diesel locomotives are built, unit cost will be reduced, and thus the present gap between relative investment costs of diesel and steam locomotives will be reduced.

Viscosity Pole and Pole Height (W_p) of Ubbelohde, S. S. KURTZ, JR., *Ind. & Eng. Chem.* **34** (1942) p. 770.

Pole height is somewhat similar to viscosity-gravity constant and viscosity index. Roughly, a paraffin base oil will have a pole height of about 1 to 2, and a naphthenic oil, a pole height of about 3 to 4. A pole height of 10 corresponds roughly to a 0.900 viscosity-gravity constant. The concept of viscosity pole is based on the fact that if viscosity-temperature curves are plotted on A.S.T.M. type viscosity paper for a series of cuts from one crude, these lines will converge toward a point. This point is characteristic of the crude and is called the "viscosity pole." The vertical height of this point above the base line corresponding to zero viscosity is defined as the "pole height."

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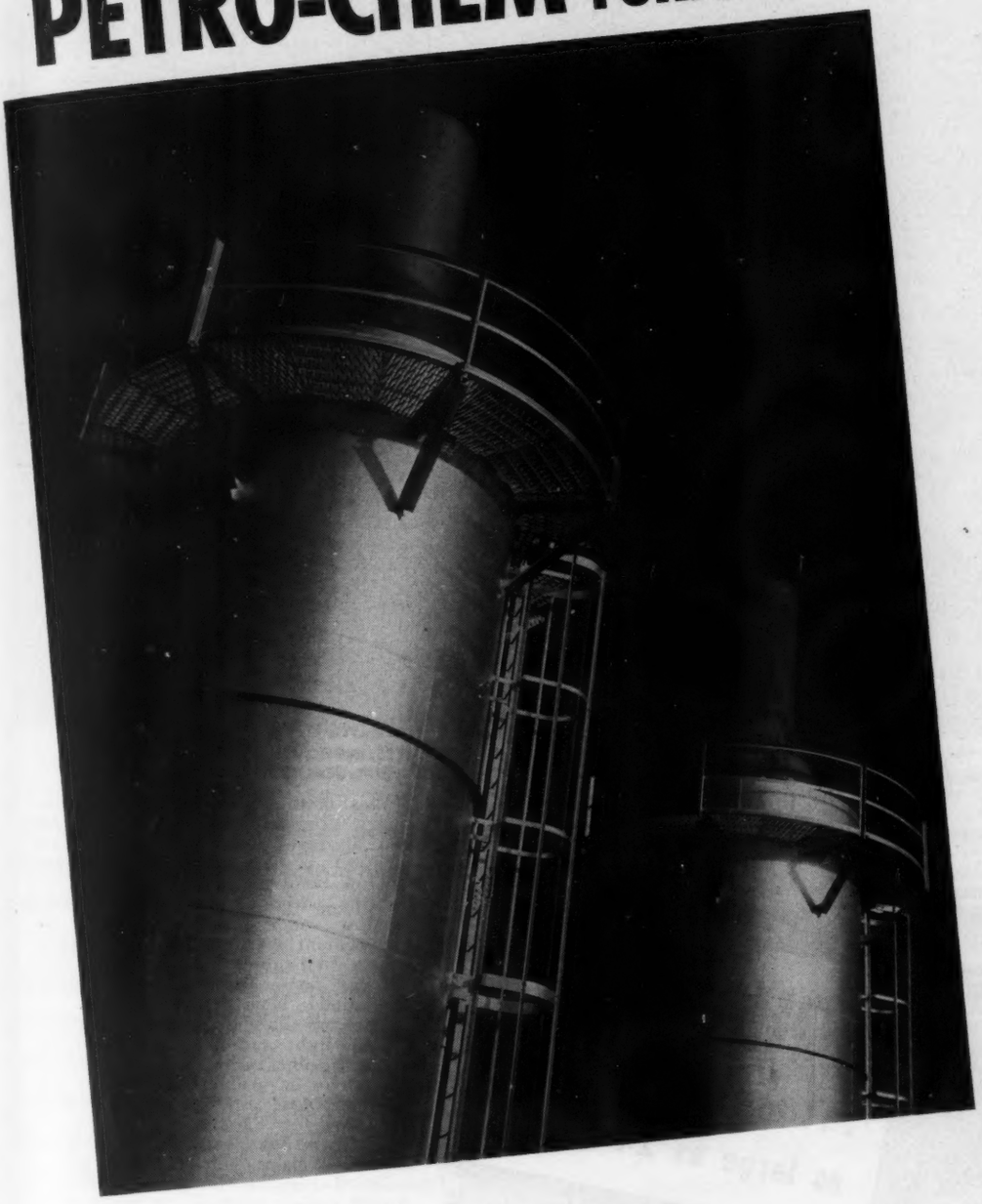

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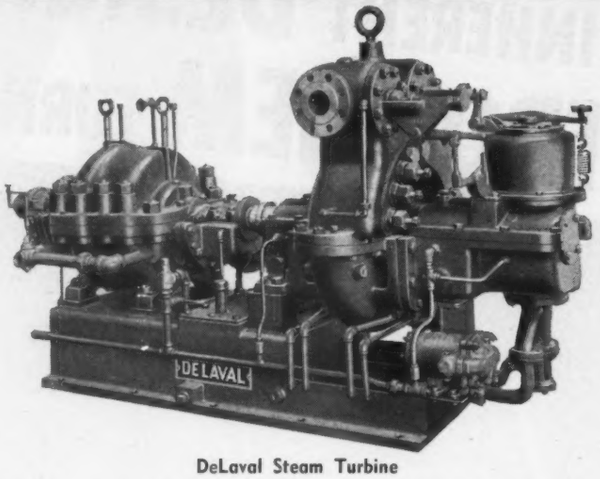
DeLAVAL STEAM TURBINE COMPANY

DeLaval Steam Turbine Company, Trenton, New Jersey, has designed its velocity stage turbines to meet modern conditions of steam pressure and temperature. For driving auxiliaries they can be connected to superheated steam mains and where the exhaust steam is used for processing, high overall economy results.

In operation from initial to final pressure, steam expands in a single set of of stainless-steel nozzles, which are screwed and welded into drop-forged-steel bodies supported by the steam-chest wall. Hand valves for individual nozzles can be fitted to make possible high efficiency under varying load or steam conditions. Steam is first directed onto the first row of buckets, which are individually fastened to the wheel. From these it enters between stationary stainless-steel guide vanes, integral with the nozzles, which redirect it into a second row of moving buckets.

The casing cover combines in one casting the steam chest and the speed-governor and emergency shut-off valve bodies. These parts, and the nozzles, are the only parts of the turbine coming into contact with steam at the initial pressure and temperature and, where the pressure and temperature of the steam are high, they are made of cast steel. The lower half of the casing is also made of cast steel where required by high-temperature exhaust conditions. The cover and attached parts are easily lifted to expose the wheel. There are no packed joints or cross-over connections to the lower half of the casing. Parts subject to the highest temperatures are remote from and above the shaft and bearings, resulting in lower temperatures of bearings and oil. For moderate steam temperatures the babbitt-lined bearings are lubricated by rings which carry up oil from reservoirs, but where the temperature of the steam at inlet or at exhaust is excessive, water-cooling or forced-feed lubrication can be provided. Also, an oil pump is provided for forced-feed lubrication in high-speed turbines.



DeLaval Steam Turbine

The turbine has a centrifugal speed governor and an independent emergency tripping device consisting of an eccentrically loaded, pivoted ring which, at a predetermined speed, releases the independent emergency shut-off valve, which has a stainless steel stem. The valve can also be tripped and reset by hand.

The powerful and sensitive speed-regulating governor, consisting of flyweights pivoted upon rockers, is either mounted on the turbine shaft or, depending upon operating conditions, on a vertical shaft driven through a worm and worm wheel. The governing action is transmitted to the regulating valve through a ball thrust bearing and a lever mounted on a needle bearing. By adjusting a spring the speed can be changed while the turbine is running. Hydraulic governors also are used, particularly where the speed of the turbine is to be regulated to control the pressure or the rate of flow set up by a pump, a blower, or a compressor. The regulating valve is of the balanced, seating type and is actuated through a stainless steel stem packed with pure asbestos rings. The emergency closing and governor regulating valves are preceded by an accessible and removable steam strainer, consisting of a heavy, monel-metal screen.

Blackout Bulb

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

Westinghouse Electric & Manufacturing Company, East Pittsburgh, has had approval from the War Department of its new blackout bulb, which can be kept burning for emergency lighting without the need for closing window shades and blinds. The announcement was made by D. W. Atwater, manager of commercial engineering for the Lamp Division, Bloomfield, New Jersey.

The new bulb gives a faint glow of orange light sufficient to clearly distinguish objects in a room but not enough to be visible from the air even though placed directly in line with an open window. In war factories, the bulbs can be installed along manufacturing aisles, on stairways and in halls. During a blackout, this light would enable workers to move about safely, switch off machinery or perform any other simple emergency operation. Although these bulbs are now available only on high priority ratings, the War Production Board may permit civilian use of the new blackout bulbs in sections of the country defined as blackout areas. This would make bulbs available for private homes, office buildings, stores, hospitals, railroad stations and trains and wherever some visibility is essential in spite of blackout.

Resembling in appearance the familiar household light bulb, the blackout lamp is coated with an outer covering of black except for an orange-red opening through which a narrow beam of

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Overloads on conveyor belts and truck tires weaken both rubber and reinforcing fabrics. Keep hose free from kinks and avoid prolonged excessive pressure. Use valves instead of kinking hose to control water flow. Never drag heavy loads by attached hose.

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light passes. The downward direction of this beam prevents any direct rays of light from being seen by planes. Operated at 15 watts, each bulb will provide emergency lighting for an area of approximately 200 square feet.

War Department regulations provide that the bulbs can only be burned in a downward position and they must be kept at least three feet away from windows or doors.

In a recent test where window shades were left up and curtains pulled aside, not a single ray of light was visible to the airmen even at low altitudes. Studies by Westinghouse engineers revealed that six times more red illumination than blue can be used before it can be detected by planes. Blue light is the most dangerous of all colors in blackouts or air raids.

Aneroid Manometer

TAYLOR INSTRUMENT COMPANIES

Taylor Instrument Companies, Rochester, New York, has introduced the Taylor Aneroid Manometer for flow and liquid-level control. The device eliminates the use of mercury or other liquid, which removes the possibility of product contamination and the hazard of mercury being blown due to line surge or carelessness. Further advantages claimed are that sealing liquids are rarely required and mercury is released for the military effort.

Taylor Aneroid Manometer

Replacing the stuffing box is a new torque-tube assembly which gives a completely closed system and is designed so as to eliminate friction and lubrication. This new assembly also does away with the lost time involved in maintenance. Friction, lost motion and wear are further reduced by the absence or internal pivots and springs.

Metal bellows respond to the pressure variations and insure faster response under ordinary circumstances with immediate reaction to sudden changes in flow. The sturdy bellows are built to withstand high over-range without damage.

Under steady flow conditions the Taylor Aneroid Manometer is accurate within 1 percent of scale range. It is available for all types of indicating and recording meters and controllers and is supplied for standard ranges between 20 and 500 inches of water. The range can be changed right on the job by substituting precalibrated torque tubes.

Welder Design

HARNISCHFEGER CORPORATION

Harnischfeger Corporation, Milwaukee, has made substitution of an all-steel portable mounting on its P&H gas engine-driven welders for the rubber tired trailer as a means of conserving rubber.

The new trailer is of the two-wheel type, equipped with an axle and heavy-duty springs, and suitable for field work and highway towing. The wheels have a 24-inch diameter and 4-inch rim face, and are designed to permit quick changeover to a pressed-steel wheel with pneumatic tire when available later. The towing bar and trailer rest have not been changed. To compensate for the harder riding of steel rimmed wheels, the new unit is built for heavy duty in every way, with a 9-leaf spring as well as extra heavy axle.

P&H executives said that the new

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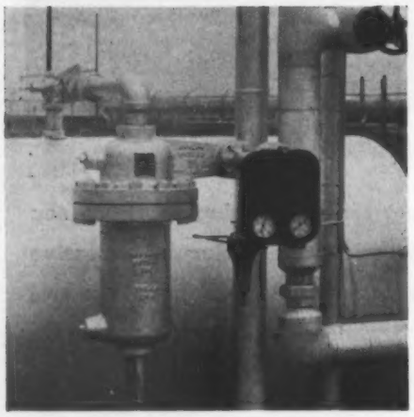

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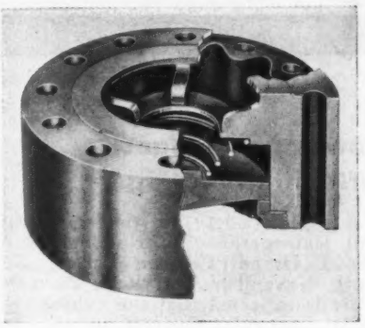
steel-wheel carriage is now being put on all portable gas engine welder shipments. This includes all Army, Navy, and Lend-Lease orders, unless specifically stipulated that rubber tires are essential. The welding range of P&H gas engine-driven models is from 15 to 370 amps.

Check Valve

THE WILLIAMS GAUGE COMPANY

The Williams Gauge Company, 2059 Pennsylvania Avenue, Pittsburgh, announces an improved line of check valves which are furnished in a wide variety of metals and sizes. Designated as the Williams-Hager flanged silent check valves, they are manufactured of bronze, cast iron, steel, stainless and monel metal for pressures from 150 to 2500 pounds to meet American standard. Sizes range from 1- to 20-inch.



Check Valve

Williams-Hager check valves have but two parts subject to wear—the valve disc and seat. Both are easily removable and renewable, and the valve can be reseated without special tools. The spring ring is now built as an integral part of the body.

These valves are recommended for use in waterworks, oil refineries, chemical works, air conditioning systems, hydraulic services, boiler feed, water supply and other non-return flow lines.

Ultra-Violet Unit

PFALTZ & BAUER

Pfaltz & Bauer, Inc., Empire State Building, New York, is offering a new pure fused quartz ultra-violet generator of high efficiency and high intensity. This unit is specifically designed for use by the petroleum industry. It is designed by practical laboratory technicians and field tested to assure a high degree of accuracy and efficiency. It is particularly adaptable for the examination and classification of bitumens, oils, lubricants, and oil shales.

Mass Production Welder

ERGOLYTE MANUFACTURING COMPANY

Ergolyte Manufacturing Company, Lawrence Street and Erie Avenue, Pittsburgh, has announced a continuous high-duty mass-production welding unit, known as 250 F. The unit contains a built-in cooling system and is heavier than its companion model 250, which is not air cooled.

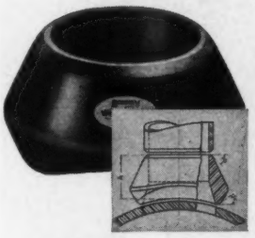
The war-time demand for virtually continuous welding prompted the development of this machine. Its makers point out that under normal conditions, naturally cooled welders get a chance to cool while their operators change rods, his assistants perform the other

WELDOLETS·
TRADE MARKS · REG. U.S. PAT. OFF.
THREDOLETS
. . . Welded Outlets for Piping . . .

How to Make Right-Angle Welded Branch Pipe Outlets Stronger, Better and at Less Cost

WELDOLETS, ThredOlets and Socket-End WeldOlets overcome every fault and weakness of pipe-to-pipe welded intersections. They eliminate all templets . . . the fitting is used as a templet . . . the necessity of cutting a symmetrical hole in the main pipe . . . shaping the end of the branch pipe to fit that hole . . . the sharp, right-angle turn which sets up stresses and weakens the junction . . . turbulence and friction, which restricts flow, caused by the sharp 90° turn.

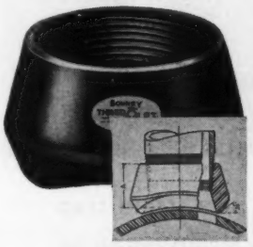
WeldOlets, ThredOlets and Socket-End WeldOlets are designed to produce wide, funnel-shaped, right-angle welded branch pipe outlets which reduce turbulence and friction to a minimum, producing better flow conditions.



WELDOLET

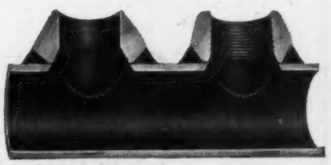
Showing the external rib and the blending of ear portion of fitting to pipe wall. Note ease of inspecting inside of joint for excess weld metal.

Their heavy, external rib amply compensates for loss of strength in the main pipe when the hole is cut . . . providing a 90° outlet with full pipe strength. This external rib and the wide base eliminates the need for extra braces to take care of bending and vibrational stresses at the junction. No templets are required for their installation.



THREDOLET

Their ease of installation and low first cost make them the ideal fitting to use in making right-angle welded branch pipe outlets. Available for all standard pipe sizes and for all commonly used pressures and temperatures, they belong in every welded piping system.

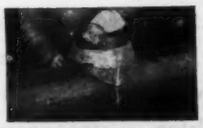


WeldOlets, ThredOlets and Socket-End WeldOlets make it possible to take branches off close together. Cutting, threading and fitting of the main pipe is eliminated.

Your local distributor will be glad to give you the full story of WeldOlets, ThredOlets and Socket-End WeldOlets or write for Bulletin WT29—TODAY.

Socket-End WELDOLET

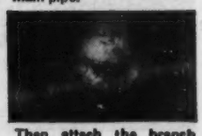
EASILY INSTALLED



Mark center lines and tack the fitting into place.

Then weld the fitting to the main pipe.

Remove the button, which will also permit inspection of the inside of joint.



Then attach the branch pipe.

Bulletin WT29—20 pages packed with information and data on advantages of WeldOlets, ThredOlets and Socket-End WeldOlets. Write for your copy NOW.

BONNEY FORGE & TOOL WORKS
FORGED FITTINGS DIVISION
ALLENTOWN, PA.

operations. Consequently, the welding machine is in almost constant use at a high-duty cycle and unless it is provided with cooling equipment the above normal temperatures will cause it to lag and eventually burn out. On the contrary, according to Ergolyte engineers, the low temperature or an air-cooled machine reduces the thermal stress which strains the insulation on ordinary machines and shortens their lives. Capable of handling an electrode from 1/16- to 3/16-inch, the new model has 24 heat steps, an input voltage of 230 volts and a current range from 15 to 250 amperes. The 250 F has a 60 cycle frequency and operates on a single phase or one phase of a two- or three-phase current. Special frequencies may be built to order.

Fire Fighting Poster

WALTER KIDDE & COMPANY

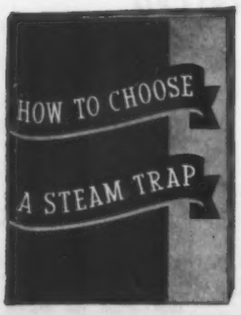
Walter Kidde & Company, 140 Cedar Street, New York, has designed a three-color poster, showing the correct method of using carbon dioxide, water and foam and vaporizing liquid fire extinguishers.

Printed in red and black, the new poster was especially designed for plant display to instruct inexperienced workers in the best methods of fighting accidental or incendiary fires. Each of the three major types of extinguisher is taken up individually. Hazards for which it should be used are stated clearly and concisely, and the method of operation is explained through text and pictures.

Kidde Extinguisher Poster

CAN YOU tell quickly what size steam trap you need on that autoclave, steam main, or header drip? Are you sure what style of trap should be used to get all the air instantly out of that steam kettle or steam chest?

These questions are simplified for holders of the book illustrated below. This free book tells what a steam trap must do . . . how it does its job . . . why air elimination is important . . . how to figure condensation rates . . . gives frequently used condensation rate tables . . . etc. Send for this useful book today—don't deny yourself its help. The book doesn't cost you a cent.



THE V. D. ANDERSON COMPANY
1942 WEST 96th STREET • CLEVELAND, OHIO

Super-Silvertop
STEAM TRAPS

Power Show Plans Fifteenth Meeting

A wide variety of timely displays will feature the 1942 National Power Show, Grand Central Palace, New York, November 30 through December 5. It is expected that the exhibits will be of particular interest to engineers and operating men who are faced with many new production and maintenance problems, as well as the many new men with industrial responsibilities.

The Fifteenth National Exposition of Power and Mechanical Engineering will be celebrating its twentieth year of service to industry. The management announces that 170 spaces have already been definitely engaged by 137 concerns, and there will probably be at least 175 displays by the time the exposition opens.

Included among the products to be exhibited are all types of valves, piping, instruments, stokers, pumps, refractories, dust collectors, steam traps and specialties, lubricants and lubricating equipment, insulation, combustion controls, boiler tubes, metals, fans and blowers, coal and ash handling equipment, engineering supplies, blueprinting machinery, metal hose, scales, packing, gaskets, electrical equipment, welding apparatus, power transmission and material-handling products, a complete line of tools for various production and maintenance uses, etc.

Management is by International Exposition Company, with headquarters at Grand Central Palace, New York.

George D. Locke Dies At California Home

George D. Locke, former vice president of Barnsdall Refining Company, died June 30 at his home in Burlingame, California. He retired several years ago and had lived in California since.

He was in charge of refining for Barnsdall Refining Company and devoted much of his time to the affairs of Western Petroleum Refiners Association, which he served as president. In 1937 he was elected to life membership in the association.

31,409,280

THIS is the number of c. c. of tetraethyl lead, a critical war material, saved per operating year by a refiner of MICHIGAN crudes, treating cracked and straight run gasolines in a Gray Catalytic Desulfurization Unit.

By using the Gray Catalytic Desulfurization Process this refiner almost completely removes mercaptan sulfur and greatly reduces the non-mercaptan sulfur in the gasoline treated.

By such desulfurization he saves 1.23 c. c. of tetraethyl lead per gallon of 70 octane number finished gasoline in an operating year conservatively estimated at 320 days, a total of 31,409,280 c.c.

THE GRAY PROCESSES CORPORATION

26 JOURNAL SQUARE · JERSEY CITY, N. J.

The Finest

THAT SKILL AND EXPERIENCE CAN BUILD

To our Railroads, America pays thankful tribute! They are doing a magnificent job in speeding troop and war material movement. Since pioneer days, our railroads have led the world in quality, efficiency and capacity. They are the finest that skill and experience can build.

But for these railroads—the shops that build locomotives, cars, rails and equipment, there had to be an abundance of water. With amazingly few exceptions, it was Layne who designed and built their Well Water Systems. Layne Wells and Pumps are famed for their high efficiency, long life and low upkeep cost.

Layne Well Water Systems, like our great American railroads are doing a magnificent job. They are standing up to unmerciful treatment—day after day and month after month of continuous full capacity operation. It is in this tragic period of emergency that Layne reliability, skillful design and rugged construction is most appreciated. Thousands of Layne Well Water Systems are serving railroads, factories, municipalities, irrigation projects and both the Army and Navy. For late catalogs, bulletins, folders, etc., address,

LAYNE & BOWLER, INC.
Memphis, Tenn.

LAYNE PUMPS & WELL WATER SYSTEMS

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Layne-Arkansas Company.....Stuttgart, Ark.
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Layne-Bowler New England Corp...Boston, Mass.
Layne-Central Company.....Memphis, Tenn.
Layne-Northern Company.....Mishawaka, Ind.
Layne-Louisiana Company.....Lake Charles, La.
Louisiana Well Company.....Monroe, La.
Layne-New York Company.....New York City
Layne-Northwest Company.....Milwaukee, Wis.
Layne-Ohio Company.....Columbus, Ohio
Layne-Texas Company.....Houston, Texas.
Layne-Western Company.....Kansas City, Mo.
Layne-Western Co. of Minn.....Minneapolis, Minn.
International Water Supply, Ltd...London, Ont.

WORLD'S LARGEST WATER DEVELOPERS

☆ BUSINESS NOTES ☆

William M. Black Elected Vice President

William M. Black was made a vice president of The American Brake Shoe and Foundry Company at a recent meeting of the board. Black has been president of American Manganese Steel Division of The American Brake Shoe & Foundry Company since 1940 and will continue in that capacity. He joined this division in 1912 and became its general sales manager in 1934 and vice president in 1935. He served as a lieutenant of ordnance in World War I. American Manganese Steel Division has six plants, the largest being at Chicago Heights, Illinois, where the general offices are located.

W. M. BLACK

Fred Jobst Takes Post With WPB

Fred Jobst is on leave of absence from Val R. Wittich, representative in New York City of Clark Bros. Company and others, to assume a special assignment with the compressor division of WPB in Washington. A graduate of Stevens Institute of Technology, before his association with Wittich, he was with Chicago Pneumatic Tool Company.

FRED JOBST

Pittman and Henry Promoted by G. E.

C. F. Pittman, manager of the motor division of General Electric Company, industrial department, has been named assistant to the manager of the industrial department. W. H. Henry, who was manager of sales in the motor division, succeeds Pittman as manager of the division.

Pittman, a native of Kansas, became associated with General Electric as a student engineer in 1911 immediately after being graduated from Purdue University. Prior to his appointment in 1929 as manager of the motor division, he had had extensive experience in many General Electric departments.

Henry was born in Terre Haute, Indiana, and was graduated from Rose Polytechnic Institute in 1914. After five years of commercial work with Western Electric Company, he joined General Electric in 1919 as a sales engineer. Since 1928 he has been closely allied with the sales of motors.

C. F. PITTMAN

W. H. HENRY

Mortensen Promoted By Allis-Chalmers

S. H. Mortensen has been appointed chief electrical engineer of Allis-Chalmers Manufacturing Company, Milwaukee. For the past 10 years he has been engineer-in-charge of a-c design.

Starting at Allis-Chalmers' Norwood works in 1905, Mortensen transferred to Milwaukee as an electrical draftsman three years later. There he successively became design engineer for d-c machines, design engineer of rotating synchronous machines, and in 1932 engineer-in-charge of alternating current design.

Mr. Mortensen was born in Denmark, studying in Europe before coming to America. He has been responsible for pioneer work in the development of self-starting synchronous motors, synchronous condensers and turbo-generators. In addition to contributing numerous articles and papers on electrical operation and design to

CHEMIST OR CHEMICAL ENGINEER

B.S. or M.S. Degree; previous petroleum refining or laboratory experience preferred. Reply must list personal and other pertinent data including starting salary. Box 604, c/o The Refiner, Houston, Texas.

Squad of Engineers capable of handling Design and Drafting on Power Plants, Chemical or Refiners. Wish employment as a group. Desire to handle complete projects. Write box 402, c/o The Refiner, Houston, Texas.

QUICK REPAIRS ON **CONDENSERS** and **HEAT EXCHANGERS**

If you need condenser or heat exchanger repairs **in a hurry** call us. We specialize in fast, high quality work.

25 Years Successful Experience

GULF ENGINEERING CO., INC.

"Service, Not Promises"

307 M & M BUILDING HOUSTON, TEXAS

916 S. PETERS STREET NEW ORLEANS, LA.

There is a NATIONAL AIROIL installation to handle that job *Efficiently*

FOR 30 years the National Airoil Burner Company has specialized on burners and furnace accessories. We have numerous installations throughout the Petroleum Industry — at home and abroad, satisfactorily burning all grades of fuels.

By collaboration with large Petroleum Refinery interests in preliminary research over a period of several years past we are prepared to supply all the types of oil burners, gas burners and furnace accessories needed for the wide variety of furnaces in the present intensive manufacture of synthetic rubber, toluene and aviation gasoline.

No matter how unusual the requirements, tell us about them and no doubt we can suggest an installation that will produce results.

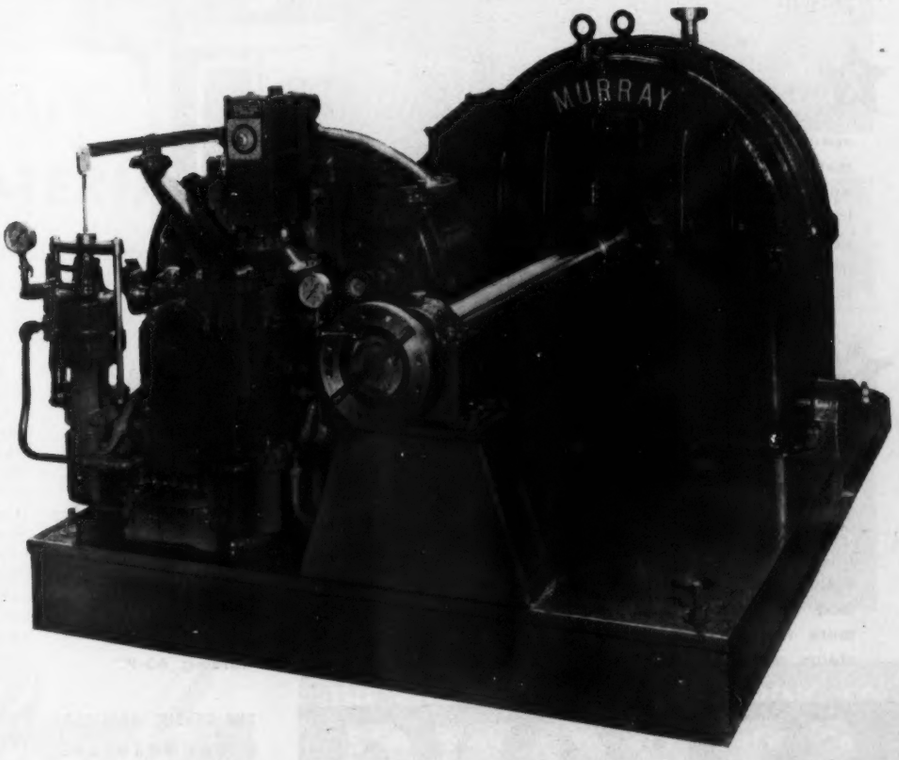
NATIONAL AIROIL BURNER

COMPANY, INCORPORATED
1254 East Sedgley Avenue
PHILADELPHIA, PENNA.

MURRAY

Type "U"

Variable Speed Geared Turbine



For drives requiring high gear ratio and variable speed, unit shown at right is particularly adapted. This unit is rated 420 H.P., 4500/400 R.P.M., 145 lb. initial pressure, 464° F. total temperature and 35 lb. exhaust pressure. It is equipped with Woodward variable speed governor linked to oil relay mechanism, and has the low speed gear shaft doubly extended. It is in operation in a large paper mill in Tennessee.

MURRAY IRON WORKS COMPANY, Burlington, Iowa

the leading professional papers, he has been the author of a textbook on Motor and Generator Design, and more recently, a co-author of the Standard Handbook for Electrical Engineers.

He is a fellow of AIEE, a member and former director of Engineers Society of Milwaukee, and the Allis-Chalmers representative for the Edison Electrical Institute.

Goodrich Sets Up New Department

A chemical and pigments department of the purchasing division of The B. F. Goodrich company, Akron, Ohio, has been recently created with Dr. V. E. Wellman as its manager.

The new department will be responsible for the development of new sources of these materials and the procurement of them for both the chemical products and rubber manufacturing divisions of the company.

Dr. Wellman, born in Denver, received his bachelor of arts degree from Phillips University and his master of science and doctor's degree in chemistry from the University of Washington.

Joining The B. F. Goodrich Company in 1929, he worked on many projects in the chemical research department, and was made manager of the chemical laboratories in 1939. Two years later he became special technical assistant to T. G. Graham, vice president in charge of manufacturing operations.

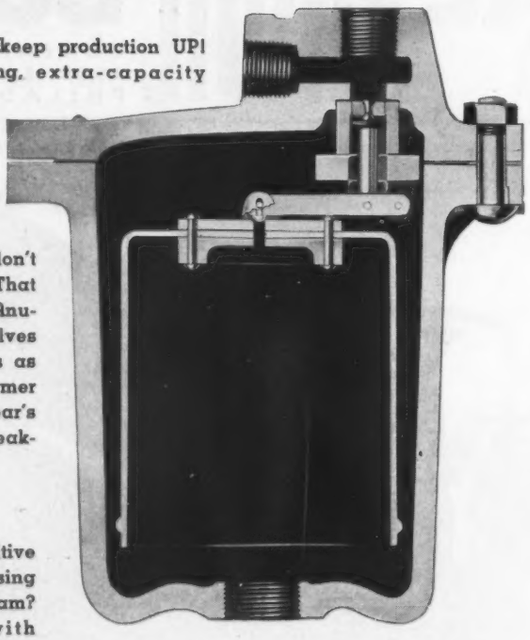
PIPEWRENCH PETE SAYS:

THESE 3 SAVINGS MAKE SENSE TO ME!

WAR!

Strong Specialties are now needed for war plants (explosives, chemicals, aircraft, ships, etc.) PLEASE CONSERVE present Strong equipment. Use repair parts to restore efficiency . . . increase production . . . save steam (fuel) . . . save money.

1 Cut down spoilage, keep production UP! Strong's positive-acting, extra-capacity traps often increase output amazingly—always keep costs DOWN!



2 Strong traps just don't seem to wear out! That special, wear-resisting Anumetl makes STRONG valves and seats last eight times as long as even Strong's former parts. You get a full year's guarantee against valve leakage or any replacement.

3 How much can positive opening and tight closing of your traps save on steam? Get these savings with STRONG'S *anti-balancing* device! Valve opens wide to discharge condensate, then closes tight—no dribbling! Positive action, plus Anumetl valves and seats can easily save more than the trap costs, in steam alone.

• MONEY-BACK GUARANTEE! Test Strong traps on your toughest jobs. If not satisfied at the end of 90 days, return them, and your money will be refunded.

HOW DO YOU SIZE STEAM TRAPS? An easy method, plus valuable information on installations, etc. Get Catalog 63-P2.

2

STRONG STEAM TRAPS

THE STRONG, CARLISLE & HAMMOND CO.

1392 West Third St., Cleveland, Ohio

•

Bonner Joins Pomona Pump Company

C. Granniss Bonner, formerly treasurer of The Brunswick-Balke-Collender Company of Chicago, has been elected treasurer of the Pomona Pump Company, Pomona, California.

C. G. BONNER

Bonner relieves Donald C. McKenna, vice president and former treasurer, who will devote full time to the increasing production activities of the company's four manufacturing plants.

Bonner is 45, a graduate of Swarthmore College with A. B. and M. E. degrees, a Phi Delta Theta and a member of the Controllers Institute of America.

James C. Tweedell Now York Sales Manager

James C. Tweedell, export manager of York Ice Machinery Corporation, has been appointed general sales manager for the duration, succeeding John R. Hertzler, who will undertake a special assignment in a civilian capacity with Army-Navy munitions board in Washington.

Tweedell, a graduate of Rhode Island State College, has been with York Ice Machinery Corporation since 1924, and has previously been assistant manager of the industrial division and manager of the commercial division. He has been manager of the export division with headquarters in New York since 1935. Prior to the war much of his time was spent abroad, in connection with the activities of York's overseas organization.

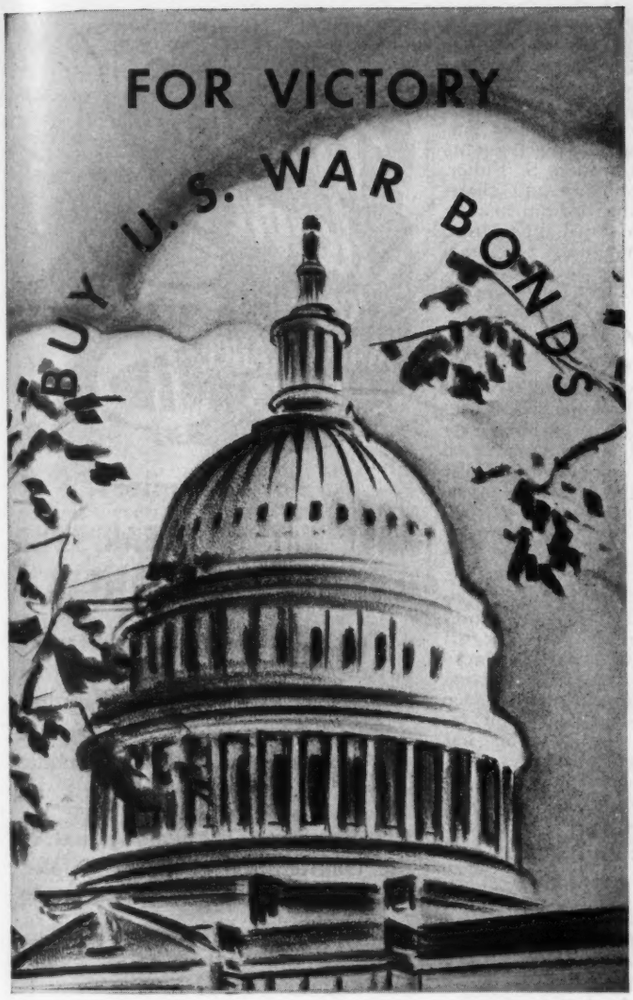
Greene Is President Of Aqua Systems

Edward L. Greene, who had been vice president of Aqua Systems, 385 Gerard Avenue, New York, since May of this year, has been elected president of the company. Aqua Systems, which was organized in April, 1925, has been a wholly owned subsidiary of the Neptune Meter Company since 1938.

Greene, a graduate of Columbia University, served as a lieutenant in the Canadian Expeditionary Force during the first world war. He also served on the staff of Lord Reading, head of the British War Mission to the United States. He was previously executive vice president of Protective Coating Corporation, director of automotive sales of Valspar Corporation and director of sales for Congoleum-Nairn. For two years prior to his joining Aqua Systems he was with Sanderson & Porter, consulting engineers.

Foxboro Company Awarded War Bond Honor Flag

The Foxboro Company, Foxboro, Mass., was awarded the Minute Man flag of the Treasury Department on July 8 in recognition of payroll allotment subscriptions by over 95 percent



—AND BUY QUALITY MATERIALS

The use of quality materials is a good guarantee against unnecessary interruptions of top-speed production. That is why Garlock packings and gaskets are in use in so many factories today.

From past experience industry knows it can rely on Garlock quality for the long, dependable service so vital in today's war effort.

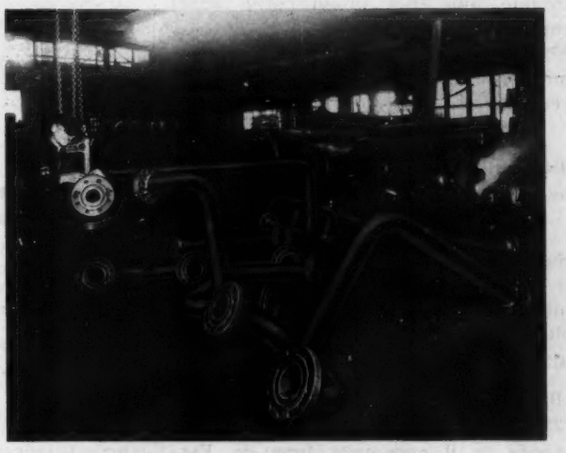
THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK
Tulsa, Okla. Houston, Texas
Los Angeles, Calif.

Garlock

WHITLOCK
PREFABRICATED PIPING

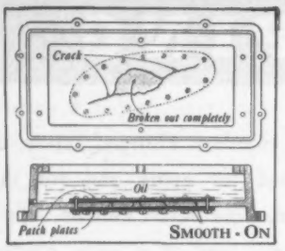
Whitlock Pipe Bends, Headers, Flanged Joints, etc., have been widely used for years and for many services. As illustrated, pipe bends can be supplied in practically any shape and in a wide range of pipe sizes and bending radii — with plain ends, cast iron or steel flanges, and with screwed, welded, or Van Stone joints.

May we quote on your needs



THE WHITLOCK MANUFACTURING CO.
75 South Street • Elmwood, Hartford, Conn.
DISTRICT OFFICES IN
New York • Chicago • Boston • Philadelphia
Detroit • Richmond

HOW SMOOTH-ON
will help you maintain production schedules



Every repair on a cracked casting or a leaking seam means loss of time which, today, may be even more important than the money cost of the repair.

To cut down repair time on many trouble jobs that would cause interruptions to production . . . use SMOOTH-ON No. 1, the iron repair cement of a thousand uses, proven by 47 years on the market.

SMOOTH-ON repairs do not require dismantling of apparatus, the use of heat, or special tools.

SMOOTH-ON is the speediest way of repairing cracks, leaks and loose parts in many cases, and the results are lasting. That is why experienced engineers all over the country always make sure to keep a can of SMOOTH-ON handy.

Buy Smooth-On in 1-lb., 5-lb. cans or 25-lb., 100-lb. kegs from your supply house or if necessary, from us. For your protection, insist on Smooth-On —used by engineers since 1895.

FREE

Dozens of time-saving, labor-saving and money-saving applications of the many purpose repair cement are described in the 40-page Smooth-On Handbook, which contains 170 diagrams showing ingenious, practical repairs to equipment all over the plant. To receive your free copy, fill in and mail the coupon.

Smooth-On Mfg. Co., Dept. 11
570 Communipaw Ave., Jersey City, N. J.

Please send SMOOTH-ON HANDBOOK

Name.....

Address.....

.....

8-42 .....

Do it with
SMOOTH-ON

of its employes. The coveted flag and accompanying certificate were presented by Alfred C. Sheehy, Deputy State Administrator of the War Savings Staff for Massachusetts, and received by Irving W. Lane, second oldest employe of the company. Arrangements were in charge of Corodon S. Fuller, an official of the company and chairman of the War Savings Committee for Foxboro. He was assisted by Alfred Herschel of the company's personnel department.

William S. Shipley Takes WPB Post

William S. Shipley, chairman of the board of York Ice Machinery Corporation, York, Pennsylvania, has been appointed director and vice chairman of Small War Plants Corporation of the War Production Board, Washington. He will direct the spending of $1,250,000,000, appropriated by Congress to assist smaller firms in getting war contracts.

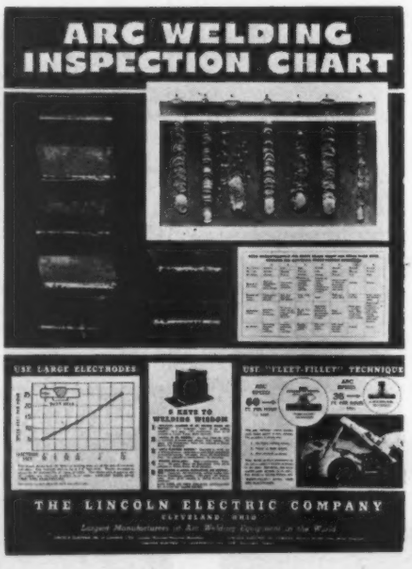
John Carr, who formerly was president of York-Shipley Company, Shanghai, China, has been appointed export sales manager of York Ice Machinery Corporation and will have headquarters at York, Pennsylvania. He has been with the company since 1925 and replaces James C. Tweedell, who has been named general sales manager.

Weld Inspection Chart Published by Lincoln

An arc welding inspection chart, which will provide welding inspectors and others concerned with weld production a simple and extremely helpful aid for use in inspecting welds, has been published by The Lincoln Electric Company, Cleveland, Ohio.

The chart presents graphically the different types of welds obtained when the work is done normally, with normal current, voltage and speed, as compared with those obtained when these factors are not normal.

"Upon inspection after welding, certain tell-tale signs will reveal considerable information to a qualified inspec-



Lincoln Welding Chart

For Example:

EASY WAY TO CLEAN YOUR ABSORPTION TOWERS

To clean their absorption towers better, as well as faster and at lower cost, many refineries are now doing this important maintenance job the easy, time-saving Oakite way.

Compared to previous practices, the Oakite method is far simpler. Merely circulating hot solution of recommended heavy-duty Oakite cleaning material through equipment as directed is all that's necessary. Most types of sludge and carbonized oil deposits on trays, bubble caps and screens are thoroughly loosened, so that these accumulations are easily removed by rinsing. Because no dismantling s required, time is saved. Normal efficiency is fully restored without undue delay.

Save Time . . . Money ON THESE JOBS, TOO!

Specialized Oakite materials and methods are also available for washing drums, de-scaling Diesel cooling systems, salvaging dirty valves, steam cleaning equipment. Helpful data FREE.

OAKITE PRODUCTS, INC.
50B THAMES STREET, NEW YORK, N. Y.
Representatives in All Principal Cities of the United States and Canada

OAKITE CERTIFIED CLEANING
MATERIALS . . . METHODS . . . SERVICE

tor," according to A. F. Davis, vice president of the company.

"Items to consider in inspection after welding include the size and shape of bead, appearance of the bead, undercut, overlap, location of craters (indicating where the operator started and stopped welding). A study of the weld and proper interpretation of tell-tale signs will disclose other conditions of welding."

These conditions are illustrated by enlarged and detailed photographs on the chart.

Accompanying the photographs is a table indicating the burn-off of the electrode, the penetration of fusion, the appearance of the bead and the sound of the arc with each value of current, voltage and speed of welding. For example, with normal current, voltage and electrode speed, burn-off of the electrode gives a normal appearance of the weld coating, a fairly deep and well-defined penetration, excellent fusion of the bead with no overlap, and an arc that burns with a sputtering hiss plus sharp cracking.

The inspection chart also illustrates the use of the "Fleet-Fillet" technique of welding, developed by The Lincoln Electric Company. The chart also illustrates how the speed of welding increases as the size of the electrode increases.

The chart is available free of charge to inspectors of welding and others concerned with welding.

Employes to Study Use of Instruments

In order that employes may gain better knowledge of construction and use of instruments, Wheelco Instruments Company, Chicago, has established a school for both office and plant workers.

Classes are held weekly, with lectures designed with two primary purposes: To broaden the individual employe's knowledge of an instrument's construction features, beyond the work done in his particular department, and to familiarize him with the instruments used in industry. The course has been planned with preliminary lectures on fundamentals of measurement and control, with later sessions to be devoted to discussions of individual instruments and their uses.

The course has been planned by Theodore A. Cohen, vice president and chief engineer of the company, who will be aided as principal lecturer by other members of the Wheelco organization and representatives of other companies. Lectures are being supplemented by motion pictures on construction and application themes.

F. H. Hill Promoted by Greene, Tweed & Company

Frank H. Hill has been elected vice president of Greene, Tweed & Company, New York, manufacturer of mechanical packings and special tools. He has been connected with the company since 1915 and has been sales manager over a long period.

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Figs. 2125 and 2129 are outstanding examples of the ruggedness and dependability that are inherent qualities in all Lunkenheimer products.

Since virtually all materials used in the manufacture of valves are on the list of critical materials, valve users are urged to furnish the highest possible preference ratings and proper "end use" Allocation Classification Symbols on their orders. This will be of mutual helpfulness.

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CATALOGS ☆ BULLETINS

Helpful Publications Which Manufacturers Will Be Glad to Send Free for the Asking

Woven Wire Products

Newark Wire Cloth Company, 351 Verona Avenue, Newark, New Jersey, has assembled a handbook on woven-wire screen and wire-cloth products, which contains data valuable to engineers who supervise either purchase or use of these materials. While part of the volume is devoted to a history of the company and a listing of its several products, the tables and other engineering information are basic for permanent reference purposes.

Centrifugal Pumps

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued an illustrated folder to give specifications of its Type CY, single-stage, open-impeller centrifugal pump. It is furnished either motor- or belt-driven.

Chemicals

Monsanto Chemical Company, 1700 South Second Street, St. Louis, has completed the twenty-sixth edition of Monsanto Chemicals, in which the complete line of its products is given in sufficient detail to "enable users of chemicals to determine whether a material unfamiliar to them is of sufficient interest to merit further consideration. All products are listed alphabetically according to their common chemical names. Where a product has more than one common name or both a trade name and chemical name, it has been attempted to list both of these along with proper cross references."

A general data section gives data on laboratory methods, physical properties of acids and other chemicals as well as tables of weights and measures.

Motor Care

Allis-Chalmers Manufacturing Company, Milwaukee, has provided a new kind of maintenance handbook, "A Guide to Wartime Care of Electric Motors," which applies to all makes of standard, general-purpose motors.

To clarify the overall problem of motor care, this new handbook treats separately each factor opposing long and trouble-free motor life. Thus the heading to the first section is "Electric Motor Enemy No. 1 . . . Dust."

Other enemies, considered in turn, are moisture, stray oil, friction, vibration, misalignment, uneven wear, overload and underload.

Last section of the booklet is a "Quick Diagnosis of Motor Ailments," broken down into symptoms one can see, can feel, can hear. Possible causes and cures appear beside each symptom.

Synthetic Rubber

The Bristol Company of Waterbury, Connecticut, has a 12-page Bulletin, No. 103, giving information concerning the application of automatic control instruments on synthetic rubber processes.

The Bulletin is liberally illustrated with typical installations and sketches showing how the instruments are applied.

Flexible Coupling

W. H. Nicholson & Company, 12 Oregon Street, Wilkes-Barre, Pennsylvania, has a new Bulletin 642, which gives details of its flexible coupling, which makes use of centrifugal force in its application. Illustrations show how the device is constructed to take advantage of this force to compensate for misalignment in drives. The coupling is described as:

"Two steel hubs which are keyed to their respective shafts and in which trapezoidal slots are cut to receive floating steel keys. Both side surfaces of the slots and the floating keys are flame hardened. The driving flanges of the hubs are widely separated to provide maximum capacity for misalignment and additional oil reservoir. Small-size couplings are equipped with three floating keys and the larger sizes with five. These comprise the working parts of the coupling and are enclosed in a malleable-iron casing made in two halves bolted together with a gasket between."

Belt Vulcanizers

The B. F. Goodrich Company, Akron, Ohio, has issued a bulletin made up of a catalog section on belt vulcanizers. It gives all pertinent details on the type of construction, dimensions, capacities and the type of current necessary for operation. A full page is devoted to a table giving all this information in condensed form. It also describes splicing tools necessary with the vulcanizers and splicing materials.

Steam Jet Injectors

Worthington Pump and Machinery Corporation, Harrison, New Jersey, has issued Bulletin W-205-B7A, which gives details of steam-jet ejectors of the two-stage condensing type. In addition to details of construction, application and materials, the bulletin gives engineering data on operation and efficiency of the units.

Water Handbook

W. H. and L. D. Betz, Gillingham and Worth streets, Frankford, Philadelphia, has available a 65-page book on chemical analyses and interpretations of water conditions for industry.

In the first section, 25 different methods of water analyses are discussed at length, with procedures and calculations. Such water analyses as hardness, alkalinity, phosphate, sulfite, turbidity, oil, calcium and specific conductance are covered. With but one exception, all tests are simple, accurate determinations requiring little or no previous chemical background. Bacteriological analyses are not included.

The second section of the book is devoted to interpretations of the tests and their application to plant control. Included here are discussions of such subjects as carbonate and non-carbonate hardness, pH control, steam purity, inter-crystalline cracking, corrosion and many others.

Scattered throughout the handbook are 16 useful technical graphs and 15 illustrations of different pieces of testing equipment.

Rubber Lining

The B. F. Goodrich Company, Akron, has issued a catalog section on Vulcalock rubber linings for handling corrosive and abrasive materials. The product is offered as a rubber lining for most inorganic acids except strong oxidizing agents such as nitric, chromic and concentrated sulphuric, as well as for most inorganic salts and alkalis and many organic chemicals now in common use. One of the valuable parts of the section is a table listing more than 100 of the most common services for which Vulcalock linings are suitable and giving the limits of temperatures and concentration of the fluid in each case.

Air Conditioning

Carrier Corporation, Syracuse, New York, has issued a new edition of its condensed catalog, listing various of its products. A new feature is a table giving a partial listing of the many war industries served by the company. Among them is synthetic rubber.

Another section groups the products ac-

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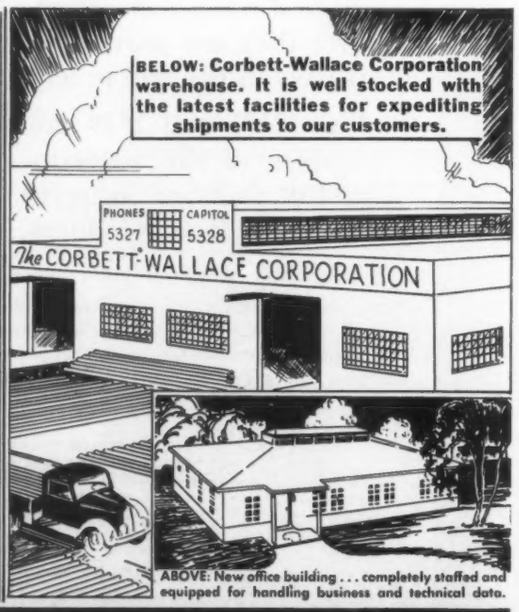
See Taylor Forge Advertisement, page 25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